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The Empire's War Effort

In our last two issues we have dealt at some length with the industrial efforts which are being made by Canada and Australia towards the successful prosecution of the war. India and South Africa are also making extraordinary progress in the production of munitions.

In India, the great Tata Company, whose blast furnaces have the largest weekly production in the world, and the Bengal, Mysore and other concerns are catering for a constantly expanding production of armaments. Under a scheme costing £5,250,000 all ordnance factories are being expanded for the production of the most modern types of weapons and munitions, including field guns, anti-aircraft guns, and non-ferrous alloys. The output of machine guns and rifles is being doubled, and increases are being registered in the output of shells, air bombs, land mines and depth charges. Plans are in hand for the immediate construction of fifty coastal patrol vessels for the Royal Indian Navy, and the building by private enterprise of shipyards for the production of steel vessels of from 8,000 to 12,000 tons.

South Africa's defence expenditure is expected to reach £30,000,000 this year, and as much as possible will be spent in developing home industries. Within the last decade, a great iron and steel industry has been established by Iscor at Pretoria, primarily to serve the mining industries of the Rand. This concern will be mainly responsible for raising the output of steel ingots to 800,000 tons per annum. The general position, and especially the potentialities, of South African industry, was ably expounded by Dr. Van Eck, the immediate Past-President of the South African Branch of the I.B.F. in an address we printed recently.

The main efforts of New Zealand, and of the forty-odd Crown Colonies, are directed towards the supply of raw materials and agricultural products for export to this country, and of course in sending a continuous supply of virile young men for the armed forces.

The Empire Air Training Scheme

Most people have some hazy notions that in Canada a scheme is under way for training large numbers of pilots and air technicians, and that these men will be available for duty next spring, but we doubt if many are familiar with this exceedingly important enterprise. Primarily, the plan covers the training of pilots, air gunners, wireless operators, navigators and observers. A board has been established in Canada under the chairmanship of a Canadian Minister, which includes representatives of the United Kingdom, Australia and New Zealand. The cost is being based on the number of airmen trained. Most men will be recruited in Canada, and 15,000 are already being trained. New Zealand is sending 500 men who have already received preliminary training, whilst the Australian contingent numbers 2,600, although the Commonwealth can, and does, provide for both elementary and advanced training within her own boundaries. For the carrying out of the scheme sixty-seven training schools are scheduled, comprising 16 service, 10 observer, 10 bombing and gunnery, four wireless, three large schools for initial training and two air-navigation schools. In addition there are a number of specialised staff schools.

For staffing the schools, there are 40,000 men, of whom 2,700 will be commissioned officers, 6,000 civilians and 30,000 enlisted men. It is estimated that 30,000 have enlisted for preliminary training and almost that number for advanced training. At least 80 aerodromes will be used, and 4,000 aeroplanes will be in constant use. When in full operation, the schools in Canada, Australia and New Zealand under the Empire Training Scheme will produce no fewer than 20,000 pilots and 30,000 air crews every year. It is expected that the cost spread over three years will be of the order of 607 million Canadian dollars, of which Britain will provide 185, Australia 44 and New Zealand 28 million dollars.

In Australia, the War Cabinet has decided that the total of recruits to March, 1943, would be 57,473, comprising 14,300 pilots, 16,173 air crews and 27,000 ground staff. This strength is to be built up by calling up from 84,000 applicants, 28,500 by June, 1941, 18,012 by June, 1942, and 10,961 by March, 1943. Thirty-six training schools are being opened at regular intervals up to April, 1942, when the scheme will be fully operative. To train fitters, the Government are establishing an engineering school with a capacity for 2,000 men. Australia is doing all the elementary training and seven months of the advanced, the balance being carried out in Canada. The training is of a particularly extended character; for instance, the wireless and gunnery courses last 20 weeks. The total expenditure on Australia's three years' air armament scheme is at present estimated to be £80,000,000.

Out of the 4,000 young New Zealanders who have registered for training as air pilots, 1,100 have been accepted. Training facilities are being rapidly extended and by the end of the year it will be possible to provide full training in New Zealand for 900 pilots annually and preliminary training for a further 500 pilots and 1,500 observers and air gunners, who will complete their training in Canada. The cost over three years is estimated at £12,700,000.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Plus or Minus in Algebraic Powers?

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have just had the opportunity to look through the August 8 issue of THE FOUNDRY TRADE JOURNAL, and would call to your attention a matter which has been more or less a thorn in the flesh of the writer at varying intervals in his work of editing the various publications produced by the American Foundrymen's Association. We would call your attention to the article by Dr. J. W. Donaldson. I have read numerous articles by Dr. Donaldson in THE FOUNDRY TRADE JOURNAL, and would not be one to criticise any of his work, as it has been exceptionally fine, especially his (what we would term) correlated abstracts of existing literature on various subjects. We would, however, point out that on page 91 and thereafter of the August 8 issue, Young's modulus is quoted as being, for example, 17.7×10^{-6} lbs. per sq. in. I am afraid that if Dr. Donaldson has read this he would not approve, for the figure means, as it is written, 0.0000177 lb. per sq. in., which, to say the least, would be an extremely small figure.

As previously stated, the use of the minus or plus signs before the power figure in large numbers has been an irksome one and has been a basis of controversy on several instances by members of the Association. If the above figure is to be written correctly, it should be 17.7×10^{6}, which means 17,700,000 lbs. per sq. in. On the other hand, on page 93 of the same issue, in Table VI at the left in the column headed "Material," the modulus of elasticity is given in lbs. per sq. in. $\times 10^{-6}$, and a whole number is shown opposite in the other columns of the table. This is quite correct.

To avoid further explanations, the following may indicate the meaning and use of the plus or minus signs before the power figure in the text.

$$30 \times 10^{-6} = 0.000003$$
$$30 \times 10^{6} = 30{,}000{,}000$$

In tabular matter, lbs. per sq. in. $\times 10^{-6} = 30$ is the same as lbs. per sq. in. $= 30 \times 10^{6}$. In reading the former, it should be read as follows:—

$$\text{lbs. per sq. in.} \times \frac{1}{1{,}000{,}000} = 30$$

The second one would read:

lbs. per sq. in. $= 30 \times 1{,}000{,}000$, or 30,000,000.

This transposition of the plus and minus signs can easily be made if their use is misunderstood, and the results obtained are often rather foolish.—Yours, etc.,

N. F. HINDLE
(Assistant Secretary,
American Foundrymen's Association).
222, W. Adams Street, Chicago.

Sir Andrew Duncan Appointed Supply Minister

Ministerial appointments made as a result of the Cabinet changes announced last Thursday include the following:—

Sir Andrew Duncan, to be Minister of Supply in place of Mr. Herbert Morrison, who goes to the Home Office; Lt.-Col. J. T. C. Moore-Brabazon to be Minister of Transport; Sir John Reith to be First Commissioner of Works; Capt. the Hon. Oliver Lyttelton to be President of the Board of Trade.

Sir Andrew Duncan, who was previously at the Board of Trade, was before the outbreak of war chairman of the British Iron and Steel Federation. Capt. the Hon. Oliver Lyttelton has since the outbreak of hostilities been acting as Controller of Non-Ferrous Metals.

Some Jobbing Foundry Experiences—IX

By "TRAMP"

What can be effected in specialised shops by metallurgical control has frequently to be achieved in jobbing shops by other methods. This is often because the melting equipment is not sufficiently efficient to produce molten iron with a high degree of superheat, and also because of the inability to tone up a mixture with steel additions, for a similar reason. Yet many tough castings are made under adverse conditions which compare favourably with the higher grade material as regards price and length of service. Fig. 1 shows a typical casting required for certain crushing operations. Hard rock is subjected to the blows of several of these castings falling on to suitable anvil blocks.

Various materials have been tried for these castings from time to time, ranging from chilled cast iron to a hard cast steel, with varying success. One jobbing foundry invariably produced a casting which stood up well on test, and although wearing somewhat quicker than the more expensive materials was nevertheless cheaper when the cost was taken over a long period. The foundry in question made these particular castings in a cast-iron chill, as did other founders who used a white hard mixture of cast iron. Invariably these latter castings fractured in service before wearing out because of the excessive hardness.

The secret of the success of the particular castings mentioned lay in the fact that a number of wrought-iron or steel bars were heated to a red heat and placed in the chill in a crosswise manner in such a way that the molten metal when cooling held them securely in position. The grade of iron used—which was not quite white—and the chilling gave the castings hardness to withstand the abrasion, and the introduction of the bars increased the toughness considerably—a simple expedient which was very effective.

Strength Features of the Tension Test

At a meeting of the American Society for Testing Materials, held recently at Atlantic City, MR. F. B. SEELY presented a Paper giving a discussion on the influence on strength values obtained from the tension test of the haphazardly progressive slips in the grains of polycrystalline aggregates. In the course of the Paper importance is placed on the conditions that change the mode of structural failure from general yielding (plastic deformation accompanied by strain hardening), associated with shearing stress, to failure by brittle fracture in which the cohesive strength of the material is exceeded, associated with tensile stress, unaccompanied by plastic deformation and strain hardening. The relation of state of stress, rate of strain, strain hardening, and temperature to these two modes of failure is emphasised; and an outline of tests to bring out information on these aspects is offered. It is pointed out that a test specimen is a model and that the significance of test results depends on the extent to which the structural action in the specimen simulates the structural action which limits the useful load-carrying capacity of the prototype or structural member. In harmony with these considerations, the general conditions under which the strength features of the tension test are especially important are defined, after which yield strength and yield points are discussed.

Random Shots

The report in more than one newspaper that Sir Robert Hadfield was "the inventor of stainless steel" only goes to prove a suspicion long held by "Marksman," that the average layman is lamentably ignorant of the most elementary general knowledge of the metallurgical world. In fact, one is tempted to think that the invention of stainless steel is the only modern development of which the man-in-the-street knows anything (and not much about that beyond the fact that his dining-table knives are always clean). In his mind, when any famous metallurgical personality comes before the public eye, his name seems to be automatically linked with the invention of stainless steel.

* * *

Before the comparatively recent national drive for the salvage of scrap metal, many people did not know for what purpose scrap was used. In those days, "Marksman" passed on his way home a certain railway siding alongside which a scrap metal dump was started and gradually assumed such large proportions that it became an object of common remark amongst the passengers of the train. The number of times that the remark "What do they use it for?" was heard was astonishing, and "Marksman" on several occasions felt obliged to chip in with an elementary lecture upon the ultimate fate of that scrap heap. Since the war began, the ordinary citizen has become considerably more alive to the existence and needs of foundries, to the extent that he now even changes the name of shrapnel to "scrapnel," and refrains from keeping too many pieces as souvenirs, realising that they can be put to better use in some foundry stock pot.

* * *

Reverting to Sir Robert Hadfield, the Editor, in his appreciation last week, pointed out how little his brilliance was suspected in his early years. He recalls a time in his youth when he used to be taken (with ears well washed and hair well brushed) to visit the home of Mrs. Eden, widow of the well-known manufacturer, Moses Eden, of Sheffield. In her youth Mrs. Eden was a frequent visitor to the Hadfield home, and used to tell a story of how Sir Robert's father was apparently quite worried about his dull son and would discuss with her what could be done about his future! It is strange how many times one hears of a similar case in the early history of prominent and brilliant men. "Marksman" himself knew of an old lady who, in her younger days, kept a small exclusive school in a French town just across the Channel. She used to recall how one of our present Cabinet Ministers was brought to her school at the tender age of seven or eight by a despairing mother, who declared that he was so dull she didn't know what to do with him! It is only fair to say that he turned out to be one of that school's most intelligent pupils. Another classic instance is that of Emile Zola, who did not pass his Baccalauréat examination, having failed in Literature!

* * *

A very junior schoolgirl was suffering from one of those same wondering glimpses into her scholastic future, the other day, for she was heard to remark, "Mummy, do you think I shall be one of those girls who wear their legs out continually walking on to platforms and their arms out for ever shaking hands with important persons?"

* * *

This week's best crossword clue comes from "The Times," and is of a type a man can understand! The clue is "a tight fit!" and the answer is, of course, "*delirium tremens.*"

"MARKSMAN."

A High-Sensitivity Radiation Pyrometer*

By N. E. DOBBINS, M.Sc., K. W. GEE, M.Sc.Tech., A.I.C., and W. J. REES, D.Sc.Tech., F.I.C.

Whilst investigating inversion points at high temperatures difficulty was encountered in observing small discontinuities in heating curves. In many cases the heats of transformation of the materials used were very small and breaks in the heating curves were not easily detectable by the use of optical pyrometers of the polarising and disappearing filament type, the sensitivity of which corresponds roughly to 20 deg. per scale division at 2,000 deg. C., and the error to be expected in a series of observations by one trained observer is of the same order. The obvious solution of the second of these difficulties was in the provision of an instrument giving a direct scale reading of temperatures, as opposed to those instruments in which the scale is set by an observer. This led immediately to consideration of the suitability of a radiation pyrometer, but experiments with one of these instruments showed that, in addition to its insufficient sensitivity, it was impossible to focus it satisfactorily on a cylindrical test-piece only 2 cm. in diameter. Therefore, in the absence of facilities for bringing larger test-pieces to the required temperatures, it was necessary to design a pyrometer specifically for the purpose required.

For some time past the authors have made use of a lens and mirror system which causes a magnified image of a small specimen inside a furnace to be thrown on a ground-glass screen, and, as the brightness of this image is a function of temperature, it was thought that a satisfactory method of determining this brightness would provide a means of temperature measurement.

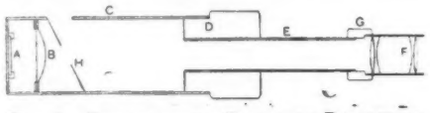


FIG. 1.—PHOTOELECTRIC RADIATION PYROMETER.

The measurement of the illumination on a surface has been carried to a high degree of accuracy by the use of photoelectric cells, and it was decided to arrange for an image of the surface of the test-piece to be thrown on a photoelectric cell.

Constructional Details

Referring to the diagram of the instrument, Fig. 1, it will be seen that a photoelectric cell, A, and its collecting lens, B, are mounted at one end of a brass tube, C. The other end of this tube is closed by a hardwood flange, D, bored to take the drawtube, E, which carries the lens, F, on the brass flange, G. The lens, a symmetrical photographic objective of focal length 8 in., forms an image of the test-piece on the screen, H, which is fitted into a slot in tube, C. An elliptical hole is cut in this screen of such dimensions that the light forming the centre part of the image of the test-piece is allowed to pass through the screen and strike the photoelectric cell. After preliminary adjustment for object distance had been made, the drawtube was locked in position, so that the area of the hole in the screen retained a constant relation to the area of surface of a hot body focused on this screen. Now, so long as the image of the hot body is brought to a focus on the screen—and this may readily be done by observing the image through a slot in the top of the tube, C—the light reaching the photoelectric cell bears a constant relation to the light emitted by a definite area of the surface of the hot body. That is to say that, whenever the instrument is brought into its working position in front of a hot body at a temperature T, the same amount of light will always fall on the cell and hence the cell itself will always cause the same current to flow in its galvanometer circuit. That the characteristics of the photoelectric cell are sufficiently constant to permit of this reproducibility of result was verified by connecting the photoelectric cell to a galvanometer and repeatedly setting the instrument up in front of a furnace running at constant temperature. It was also determined that the visual observation of the image on the screen provided a sufficiently sensitive method of focusing to ensure that consistent results were obtained.

The galvanometer employed was originally intended for use with a thermocouple and was scaled from 0 to 1,200 deg. Calibration of this against a millivoltmeter of 20 ohms internal resistance was carried out by connecting the photocell alternately to the two instruments and showed a straight-line relation between millivolts and galvanometer readings in degrees, each 10-deg. division on the galvanometer scale corresponding roughly to 0.03 millivolt.

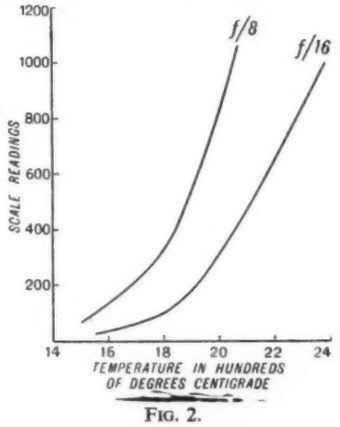


FIG. 2.

Calibration Curve

A calibration curve for the pyrometer was obtained by setting it up in front of a surface of which the temperature had been observed by means of an optical pyrometer. Sufficient readings at each of different temperatures were taken to allow the mean temperature recorded by the optical pyrometer to be accurately plotted against the galvanometer reading. The results obtained are shown by the graphs in Fig. 2. The curve marked f/8 indicates the calibration when the lens is used at its full aperture, whilst that marked f/16 shows the calibration when the iris diaphragm of the lens is closed down to this stop number.

The advantages of the pyrometer may briefly be detailed as follows. First, it is much more sensitive than the usual type of optical or radiation pyrometer, the sensitivity of these instruments lying between 10 and 20 deg. per scale division at 2,000 deg. C., whilst the calibration curves for the photoelectric pyrometer show that its sensitivity is 4 deg. per scale division at this temperature, using the lens at f/8, and 6 deg. per scale division at 2,400 deg. C., using the lens at f/16. Since it is possible to read a galvanometer to one-tenth of a scale division it will be seen that, whilst the accuracy of the actual temperature recorded by the pyrometer will depend on the method by which the calibration has been performed and the care with which the instrument is used, an alteration in temperature of 0.5 deg. C. at 2,000 deg. C. can be detected by close observation of the scale, whilst an alteration of 1 deg. C. at the same temperature produces an easily observed deflection of the pointer. It may be emphasised that observations of this type are dependent only on scale readings and do not involve any process, such as the matching of brightnesses, liable to human error.

Small Target Area Needed

Secondly, the target area needed for observation is very small, a circle of 2 cm. diameter being ample when the instrument is set so as to record at a distance of about 2 ft. from the hot surface, this being of especial advantage in experimental work with small surfaces. The instrument could readily be adapted to read on smaller surfaces at greater distances by using a lens of larger aperture, in order to collect more light, and thereby making it possible to reduce the size of the hole in the screen so that it would be covered by a smaller image. Whilst a focusing adjustment could have been provided which would have allowed the instrument to be used at varying distances from the hot surface, this has not been done as the position of the pyrometer is itself easily adjusted.

Examination of the calibration curves will show that whilst at low temperatures the sensitivity is small, it increases with the temperature until, on the straight portion of the curve, a very high degree of sensitivity is reached. Reference to these curves shows that by suitable adjustment of the diaphragm of the lens it is possible to arrange that any desired temperature will fall on the straight portion of the curve—that is, so that the instrument can be made to show its maximum sensitivity at the temperature at which it is desired to work. Mention should be made of the fact that this pyrometer, in common with all others, will not read through fumes, and if advantage is to be taken of its high sensitivity, scrupulous care must be taken to avoid these. The presence of traces of fume may lead to discontinuities in heating curves which should not be present, and which would not be recorded if a less sensitive pyrometer were being used.

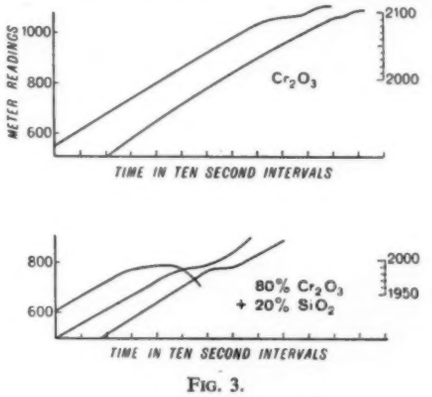


FIG. 3.

Two sets of heating curves, one for pure Cr_2O_3 and the other for a mixture of 80 per cent. Cr_2O_3 and 20 per cent. SiO_2, obtained by the use of the photoelectric pyrometer are given in Fig. 3. The curves represent galvanometer readings plotted against time, but the equivalent temperatures are marked on the right-hand side of the graphs for the region of the melting-point. It will be seen that the curves give a precise indication of the melting temperatures. Experiments have been made on a differential method, involving the use of a composite specimen and a mirror system which split the image into two parts, each of which was received

(*Continued on page* 238.)

* Reprinted by courtesy of the Council of the British Ceramic Society from the August issue of the "Transactions."

Centrifugal Casting

BENEFITS DERIVED FROM THE PROCESS

Writing in "The Iron Age" on the centrifugal-casting process, its limitations and advantages, J. D. Zaiser (Ampco Metal, Inc., Milwaukee) states that the basic requirement in centrifugal casting is for mechanical equipment capable of wide speed variation (from 50 to 3,000 r.p.m. if a variety of work is to be done), to which can be affixed a mould or die for use in actual production. Mechanical drives are usually used, although most of the machines at the works of the author's company are hydraulically powered. A hydraulic drive was chosen for several reasons, among which were infinite speed variation, convenience of remote control of centrifugal spindles, and the cushioning effect of hydraulic power against shocks, together with the elimination of high-speed gearing requirements. One drive pump takes care of five spindles or centrifugal machines, and the layout is so made that from one to five machines can be operated simultaneously, at the same or differing speeds. This hydraulic drive system, which has been in constant use for over 18 months to date, has proved entirely satisfactory.

Mould Equipment

Mould equipment varies widely, dependent upon the design or construction of basic equipment, and the type of castings being produced. Most common is a steel or iron shell, dynamically balanced, with suitable fixtures for attachment to the driving unit. The mould, usually of core sand composition or a variation thereof, is rammed up in this liner and the whole unit baked in a core oven. In some cases, the shell is used as a housing or retainer only, and the liner baked in a separate shell, liner and shell then being slipped into the retainer for casting.

A mould such as this is suitable for the production of only one casting, as the sand liner is broken up in removal of the casting. For high production runs, steel or iron moulds are used, the inside contour of which is machined to the desired outside contour of the castings to be made. Compositions of such moulds will vary, many of them being inexpensively made of alloy cast irons of the type usually used for billet mould production. Production equipment of this type can be used for from 30 to 80 castings before redressing. After a certain number of pieces have been made, redressing is necessary, for heat cracks will have appeared in the mould, or its surface will have been roughened or abraded, making casting removal difficult, and the castings themselves unsightly.

Castings produced by the baked-sand liner method require little, if any, taper from one end to the other, since the mould is destroyed in the shakeout. With metal or permanent dies, a slight taper of the order of ¼ in. per ft. on the diameter is employed, so that the casting quickly frees itself for removal and does not wear the mould surface unduly.

Pouring and Rotating

Regardless of the type of mould used, a cover is placed over the end from which the liner is inserted or rammed up. Pouring of the metal may be handled in several ways, the most common of which is pouring directly into the mould through a hole in this cover plate, which procedure is usually wholly satisfactory for comparatively short pieces. In the making of long thin-walled castings, this same procedure is sometimes followed, but usually only when the mould is inclined rather than fully horizontal. Other methods are used in some plants whereby the molten metal is either poured along the whole length of the casting by means of a trough which can be filled, inserted into the mould and then dumped, or poured through a retracting spout which moves from the rear end of the mould forward during pouring.

Centrifugal castings are usually made in dies or moulds revolving about a horizontal axis. However, operation may be either about a fully vertical axis or one which is inclined at some desired degree to the horizontal. The choice is usually governed by the type of casting being produced as well as the limitations of equipment available. Long pipes and cylinders, for example, lend themselves best to production about an axis that is horizontal or nearly so, whereas short pieces, such as gear blanks, are frequently produced on fully vertical machines.

Rotative speeds during casting will vary with the work at hand. As far as casting shape is concerned, the speed need be only enough to hold the metal against the mould wall. At the other end of the scale, it may be reasoned that the higher the speed of rotation, the greater will be the compacting and cleaning action due to centrifugal force. The factors of cooling, shrinkage, hot-metal strength, and liability of segregation of metal ingredients must all be considered in establishing proper speeds, however, and as these will all vary from one alloy to another, the "cut and try" method frequently takes precedence over the engineer's slide rule, with past experience and case histories the guiding influence.

Wide Variety of Castings Made

While it is true that not all shapes of castings can be made centrifugally, experience, improved equipment, and progress in methods have greatly increased the range of work that can be spun advantageously. Plain cylinders or bushings are, obviously, easiest to produce and comprise the greatest overall centrifugally cast tonnage. In a general sense any variation of this basic shape can be produced, the greatest limitation being that the inside diameter of the casting must be either a straight bore, or one which can be machined to the required contour without too great a machining cost or metal loss, a good example being a controllable pitch propeller bushing, of which some 40,000 have been produced to date. As an example of the range of work being done, the weight of parts being centrifugally cast in bronze at the author's plant ranges from the smallest of 1½ lb. to the largest to date, 3¾ tons, and diameters vary from 1¼ in. to 54 in.

Most copper-base alloys or metals can be cast centrifugally, although casting practice must often be varied from one alloy to another by virtue of the metal characteristics themselves. The greatest problems are presented by so-called alloys which are in reality mixtures, in that the ingredients do not alloy one with the other.

The copper-lead series is one such material. Lead and copper will not alloy, and by virtue of their differing specific gravities and melting points, a metal containing these two ingredients alone is one of the most difficult non-ferrous alloys to produce. Copper-leads can be centrifugally cast with close attention to (1) chill effect so that the lead solidifies rapidly and without time to segregate into objectionable large particles; and (2) careful speed control, set (and corresponding casting pressure) well below that which would be used for production of castings from a true alloy. The spinning of this type of metal is usually confined to straight bushing stock having a wall thickness not exceeding 1 in.

Another alloy series which can be centrifugally cast is the copper-tin-lead group, a familiar example of which is 80:10:10, or phosphor bronze. Inasmuch as the presence of tin makes this an alloy rather than a mixture, higher rotative speeds can be used. Here the primary difficulty is the hot-shortness of the alloys, or low strength at high temperatures, which tends to cause the formation of fissures or cracks during the casting operation, unless proper control of speed, pouring temperature, and chill effect is exercised. With this alloy series, more complicated shapes and heavier wall sections can be successfully cast.

Alloys of the aluminium-bronze class are ideally suited for centrifugal casting, the main precaution necessary being that composition must be carefully controlled because of the aluminium losses which may be abnormally high due to excessive drossing caused by turbulence in the casting operation. Hot strength and homogeneity of the alloy are good, and chill effect is of no great consequence; therefore, mould materials can be chosen without particular regard to the requirements of the alloy itself, and high casting speeds may be freely used. Complicated castings and very heavy wall sections can be produced in the aluminium bronzes.

Many other alloys including manganese bronze, nickel bronze, beryllium copper, and Monel metal are adaptable to centrifugal castings. Most of these have certain peculiarities which must be taken into account, but which can be compensated for on the basis of casting experience.

Advantages of Process

The advantages of the centrifugal casting process are many. The greater demands made on metals by modern industry have in some cases led to a distrust of castings for heavily stressed parts because of a sometimes over-emphasised fear of casting defects. As a result, many parts have been made from forgings or wrought materials at a very appreciable premium paid in the form of metal waste in machining, and high machining costs. That such parts, when of suitable design, can be made centrifugally at a definite saving is vouched for by, to mention one well-known instance, a large motor company's use of this method for transmission cluster gear production.

Many manufacturers are changing gears, feed nuts, and similar parts from sand to centrifugal castings because of the assurance of sound material and the consequent savings in machining costs through eliminating the liability of having to scrap not only material but also machining time on even a small percentage of defective sand castings.

The explanation for uniform soundness in spun castings is simple enough. Sand-cast cylinders solidify progressively from both outside and inside surfaces. As a result of the fact that minute impurities in the metal are not trapped progressively in this chilling but tend to travel ahead of the solidifying crystals, any such impurities are concentrated where the two grain growths meet. This phenomenon is true of all statically cast metals, whether ferrous or non-ferrous, and is worthy of consideration. It is conceivable, for instance, that in the case of a feed nut the base of the nut threads would lie in this weakened zone.

Since in centrifugal casting the metal freezes from the outside surface only, there is no possibility of the above condition occurring. Furthermore, centrifugal casting largely eliminates so-called columnar growth of metal grain, breaking these columns into shorter, more closely inter-knit sections, having greater strength and homogeneity.

The oxides of most metals are lighter than the metal itself, as are gases and possible non-metallic inclusions, such as bits of furnace lining, fire brick, or similar materials that might be present in a bath of molten metal. Skimming

(*Continued on page* 242.)

Influence of the Mould on Shrinkage in Ferrous Castings*

By H. L. WOMOCHEL and C. C. SIGERFOOS

In conducting an investigation to determine the influence of mould conditions on the microstructure of cast iron, a number of 8-in. by 1.2-in. bars were cast from the same ladle in open moulds of various types. It was observed that a marked difference existed in the piping tendency in the moulds.

Fig. 1 shows cross-sections of the tops of three of the bars. The casting labelled "green" was poured in a synthetic green sand, and the one marked "core" in an oil-sand core. The dry mould was prepared from silica sand, bentonite, and a small percentage of a plastic refractory, and was ignited at 870 deg. C. to remove moisture and organic material.

These results indicated the possibility of some relation between mould material and shrinkage defects in castings made in closed moulds. A number of castings were made from several patterns in green sand and core sand to determine the extent of the influence of the mould. Fig. 2 illustrates cross-sections of three castings poured from the same ladle in the order shown. The dimension of the casting at the widest point is 2¼ in. Castings 1 and 3 were made in two types of core sand and casting 2 in green sand from the foundry floor. The moulds were horn gated and no risers were used.

Casting 2 (Fig. 2) shows a sinking of the cope face of the heavy section, and a constriction of the light section. The machined surfaces of the castings were ground smooth and subjected to a prolonged etch. No internal porosity was revealed.

The difference in shrinking tendency between the dry and green moulds suggested the likelihood of some influence of the various kinds and conditions of green sand on shrinkage defects. A number of experiments have been conducted to investigate this possibility.

Fig. 1.—Effect of Mould on Piping Tendency.

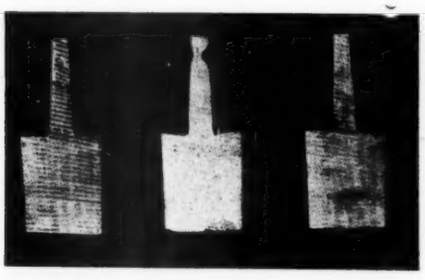


Fig. 2.—Sections of Castings from Core-Sand and Green-Sand Moulds.

Fig. 3.—Effect of Mould Hardness on Piping Tendency.

Fig. 4.—Effect of Green Compressive Strength on Piping Tendency.

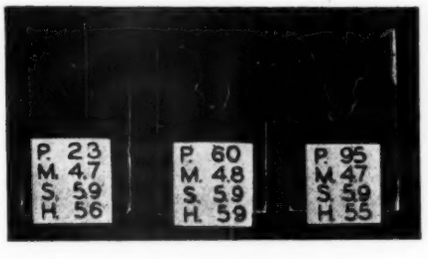


Fig. 5.—Influence of Permeability on Piping Tendency.

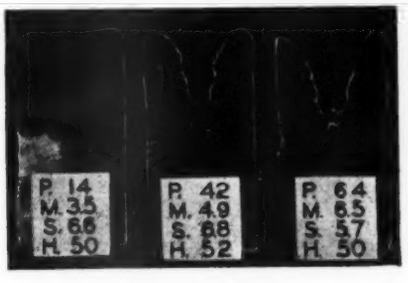


Fig. 6.—Effect of Moisture on Piping Tendency.

Results Obtained

The castings made in the preliminary tests showed a correlation between the small bars cast in open moulds and castings poured through a gate in a closed mould. It was decided to employ the top-poured bar as a convenient test casting for experiments to determine the direction of the influence of such factors as mould hardness, permeability, moisture content, and green compressive strength.

The grey iron for these experiments was melted in an indirect-arc electric furnace. The metal compositions for the series of vertical bar castings were within the following limits: C, 2.75 to 3.00; Si, 2.15 to 2.40; Mn, 0.70 to 0.90; S, 0.07 to 0.10; and P, 0.10 to 0.20 per cent. The charges consisted of returns, pig, steel, and malleable scrap. A late addition of 0.25 per cent. or more of silicon as 75 per cent. ferro-silicon was made to the furnace immediately before tapping. Tapping temperatures were in the range 1,510 to 1,575 deg. C. Pouring temperatures were in the range 1,412 to 1,440 deg. C., as indicated by an optical pyrometer. The carbon content was regulated by graphite addition after the melt-down. An examination of sections from the 1.2-in. by 8-in. bars showed a normal structure in most cases. Most of the sands used in these experiments were prepared by mulling mixtures of lake sand, bank sand, and a sand containing 28 per cent. clay.

All of the castings shown in any one illustration were poured from the same ladle, unless otherwise indicated. Variations in metal temperature, resulting from cooling in the ladle during pouring, were minimised by pouring as rapidly as possible. In checking these experiments, the order of pouring was reversed with no apparent effect on the results obtained.

Influence of Mould Hardness

Fig. 3 shows the influence of mould hardness. Casting 1 was poured into a core-sand mould. Casting 2 was cast in a green-sand mould, rammed to an average hardness of 90 as determined by a mould hardness tester. Castings 3 and 4 were poured in moulds of the same type rammed to a mould hardness of 50 and 5 respectively. Casting 4 was swollen at the lower end.

These results show the relation between piping and swelling. In the case of a very soft mould, swelling evidently continues for some time after pouring has ceased and the casting has partially solidified. The volume occupied by swelling is fed by piping or "shrinkage." This experiment was checked using cylinders of 2-in. dia. with identical results.

Effect of Green Compressive Strength

Fig. 4 shows the effect of green compressive strength. The castings shown are the top sections of bars 1½ in. in diameter and 12 in. long. In this and subsequent illustrations, P refers to permeability, M to moisture content, S to green compressive strength, and H to mould hardness.

A base sand, consisting of a mulled mixture of the previously mentioned clay containing sand, floor and lake sands was employed. The green compressive strength was raised from 2.8 to 9.1 by additions of bentonite. Moisture and mould hardness were kept as nearly constant as possible. These castings were moulded by squeezing a plate in a 3½-in. cope and drag. The moulds were poured on end, through a hole in the flask, at the parting line.

This experiment indicates that, rammed to equal hardness, the low green-strength sands have less tendency to cause piping than high-strength sands when the increase in strength is produced by additions of rich clay. The hardness values are the average of a number of readings taken at fixed points on the parting surface. The values for permeability and green compressive strength were obtained from the standard laboratory tests in all of these experiments, and do not refer to mould values.

Influence of Permeability

Fig. 5 shows the effect of permeability. A base sand consisting of bank sand and the clay-containing sand was used. The permeability was increased from 23 to 95 by substituting lake sand for the bank sand in increasing proportions. Moulding was conducted in the manner

* Paper presented to the Chicago Convention of the American Foundrymen's Association. The authors are on the staff of the Michigan Engineering Experiment Station, East Lancing, Mich.

described for the previous experiment. The piping tendency is increased with permeability when this property is altered by changing the grain size of the sand.

Influence of Moisture

Fig. 6 shows the influence of moisture. Sand was taken from a heap on the foundry floor and the moisture varied from 3.5 to 6.5 per cent. The permeability increased with the moisture. This sand and the sands of Figs. 1 to 5 contained no coal dust.

Influence of Coal Dust

Fig. 7 illustrates the effect of coal dust. The letter C on the illustration refers to the percentage of coal dust by weight. A mixture of heap sand, clay-containing sand, bank sand, and lake sand was used as a base. The permeability and green compressive strength were kept constant by varying the proportions of the constituents. This experiment shows that coal dust has a remarkable effect on the piping tendency when it is added to a sand and the permeability and green strength are maintained.

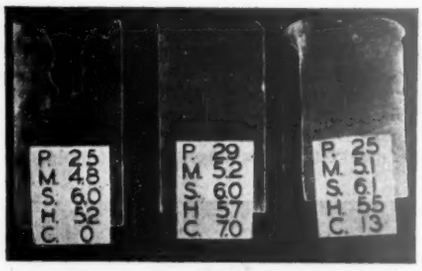


Fig. 7.—Relation between Coal-dust Content and Piping Tendency.

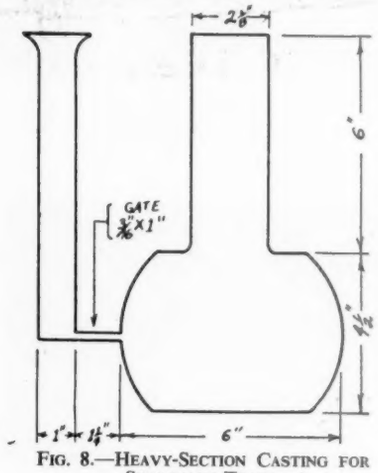


Fig. 8.—Heavy-Section Casting for Shrinkage Tests.

Results Applied to Heavy Castings

To determine the extent to which the results of Figs. 3 to 7 could be applied to heavy castings made in closed moulds, a series of experiments was conducted using the casting shown in Fig. 8. The pouring temperature for the heavy castings was 1,412 to 1,440 deg. C., unless otherwise indicated. Moulds for the heavy castings were made by hand ramming followed by squeezing. The gated pattern employed was mounted to a match plate. During these experiments, a fillet was added to the pattern at the junction of the riser and casting. This fillet does not appear on all of the castings in the photographs.

With the exception of the experiments shown in Figs. 19, 20 and 21, the heavy castings were cast in sands prepared by mulling mixtures of lake, bank and clay-containing sands as previously described.

Core Sand versus Green Sand

Fig. 9 shows a comparison of core sand with green sand, and with green sand plus coal dust. The metal composition was:—C, 2.96; Si, 2.32; Mn, 0.78; S, 0.072; and P, 0.18 per cent. In this and subsequent figures, "Hard" refers to mould hardness determined by averaging a number of readings taken at fixed points on the mould surface; "G.C.S." indicates green compressive strength; "Perm," permeability; "Mois," moisture; and "Bent," bentonite. The results of this experiment are in agreement with those of Figs. 2, 3 and 7.

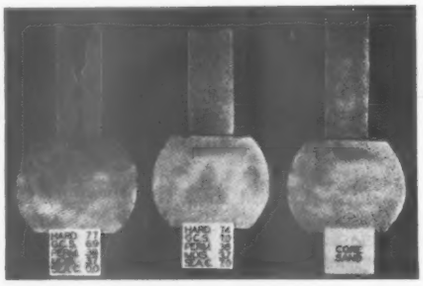


Fig. 9.—Core Sand compared with Green Sands.

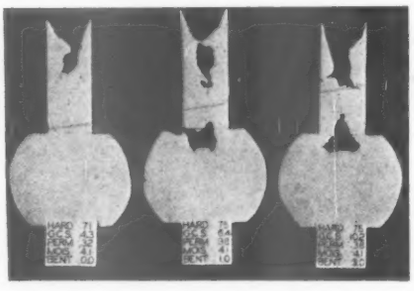


Fig. 10.—Effect of Green Compressive Strength.

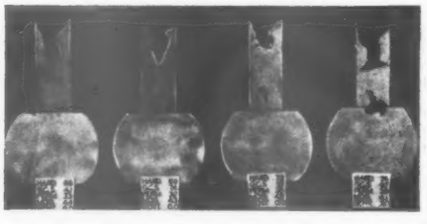


Fig. 11.—Effect of Green Compressive Strength.

In a separate experiment (not illustrated) the composition of the core sand was varied through wide limits of oil and cereal content with no appreciable effect on piping or soundness of the castings.

While conducting this investigation, a number of moulds were sectioned and hardness readings taken at various points beneath the surface. These tests indicated that readings taken on the mould surface were representative of the hardness throughout the mould.

Influence of Green Compressive Strength

Fig. 10 shows the influence of green compressive strength. A base sand of bank, lake and clay-containing sands was employed. The green compressive strength was increased from 4.3 to 10.2 lbs. per sq. in. by additions of 1 and 3 per cent. bentonite. The results agree with those of Fig. 4. An addition of the bentonite produced an appreciable increase in permeability. The metal composition was:—C, 2.93; Si, 2.11; Mn, 0.77; S, 0.064; and P, 0.15 per cent.

Fig. 11 also shows the influence of green compressive strength. The sands for castings 1, 2 and 3 (left to right) were prepared by mulling mixtures of the clay-containing, lake and bank sands with increasing proportions of the clay-containing sand to raise the strength from 4.1 to 9.7 lbs. per sq. in. The permeability was maintained by varying the proportions of lake and bank sands. The sand for casting 4 was the same as that for casting 1, except that 3 per cent. bentonite was added. Comparison of castings 1 and 4 shows good agreement with Fig. 10. The difference between castings 3 and 4 would indicate that the manner of adding clay has an effect on the results.

It should be noted, however, that the distribution of the grain size of the sand is not controlled in this experiment. The presence of fines or pan material doubtless affects the distribution of clay and moisture, and may have an influence on piping tendency. The increase in the amount of clay-containing sand probably altered the grain-size distribution to a much greater extent than did the addition of 3 per cent. bentonite. The metal composition was:—C, 3.11; Si, 2.26; Mn, 0.83; S, 0.068; and P, 0.13 per cent.

(*To be continued.*)

Publication Received

Ceramic Glazes. By Felix Singer. Published by Borax Consolidated, Limited, Regis House, King William Street, London, E.C.2 (temporary address, Oxshott, Surrey).

Recipients of this 100-page booklet can indeed count themselves fortunate, as it covers in the most complete manner the subject of glazes and their application. After reviewing the general properties of glazes, a study of the raw materials is given, followed by extensive notes on its fusibility; eutectic mixtures; classification of glazes; glaze compositions; leadless earthenware glazes; and a series of special glazes.

The part dealing with the application of glazes is divided into three sections, covering the adaptation to the body, glaze defects, and the influence of glazes on the mechanical strength of ceramic bodies. Though primarily intended for ceramists, the booklet is of equal interest to vitreous enamellers. There is a very complete bibliography for use by those desiring to delve still more deeply into the subject, whilst the nine appendices contain a mass of readily utilisable data. The booklet is particularly well indexed. A limited number of copies of this publication has been reserved for our readers, but early application is essential.

A High-Sensitivity Radiation Pyrometer

(*Continued from page* 235.)

by a separate photoelectric cell, but it was found that the indication of change points given by this method was no more precise than that given by straight heating curves, and it was concluded that, so long as the rate of heating of the furnace could be kept uniform, there were no advantages to be gained by using the rather more tedious method involving differential temperature readings.

In conclusion, it should be pointed out that a pyrometer of this type would be especially valuable in various works processes in which the accurate control of temperature is desirable. As previously stated, the apparatus can be adjusted to give its maximum sensitivity at any working temperature, and it is reasonable to suppose that under works conditions a variation in temperature of ± 1 deg. C. could be recorded. It would, indeed, be possible to arrange a mirror galvanometer system which would throw a spot of light on to a second cell whenever the temperature deviated from that required by ± 1 deg. C., and this second cell could be set to work a relay and give either visual or audible indication of the deviation.

The Running of Castings*

By FELIX HENON

Mould Filling

Any preliminary study of the casting up of a mould includes a combination of the following factors:—(1) Filling the mould with essentially sound metal; (2) avoiding the deterioration of the mould by the liquid metal; (3) directly evacuating the gases; and (4) feeding the massive parts of the casting during solidification.

Measures to be taken to control these four factors include:—(1) The method of filling, that is, the method by which the liquid metal is transferred from the ladle to the mould; (2) the type of runner, which controls the disposition of the gates carrying the liquid metal into the main mould cavity; (3) the rate of casting; (4) the position and dimensions of the risers and feeding heads; (5) the position of the mould during casting; (6) the temperature of the mould; and (7) the casting temperature. Casting up is an important phase in making a casting and has often a preponderating influence on its successful production. It is obviously desirable to establish full details before starting.

In what follows, it is proposed to study several methods of filling and the types of gating most usually employed. Some simple examples of application will be given. Attention will be drawn principally to the following points:—Clean metal; movements of metal in the mould, notably the speed of its arrival in the mould cavity, and the speed of casting.

Clean Metal

Clean metal for casting is obtained solely by keeping back the liquid slag and the solid elements which can leave the ladle. This cleanliness can be ensured by filtering or by applying the fact that the impurities in the metal are nearly always lighter than the metal itself. In the latter case the runner basins are so arranged that the impurities remain there or turbulence is created for their retention.

The sketches referred to later are not to scale, but are only schematic. For the sake of clarity the sections of the gates are distinctly exaggerated.

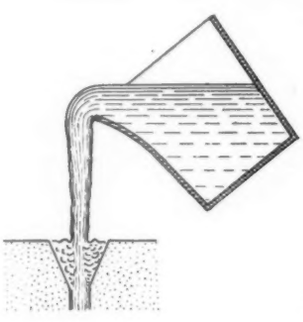


Fig. 1.

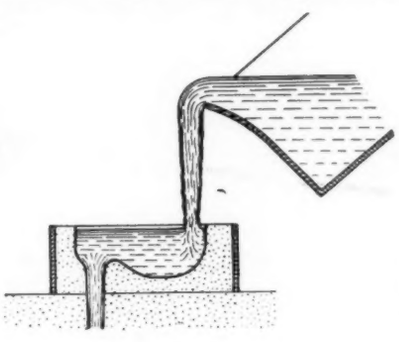


Fig. 2.

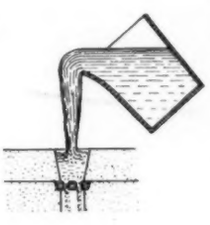


Fig. 3.

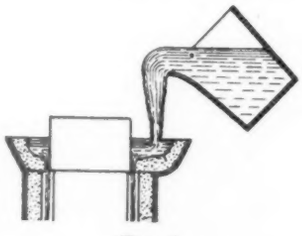


Fig. 4.

Methods of Mould Filling

Tipping Ladle Pouring Directly into the Runner.—This method of filling is the simplest and is shown in Fig. 1. The use of a skimmer prevents to a certain extent the passing of ladle slag into the mould. The impurities in suspension do pass, however. It is essential to maintain the runner top always full, so as to give an opportunity for the impurities to rise to the surface and so not enter the mould. This precaution gives the additional advantage of preventing the entry of air.

Tipping Ladle Pouring into a Runner Basin.—This method of casting is shown in its simplest form in Fig. 2. The cup being maintained full during casting, the slag and the impurities lighter than the metal remain on the surface. Entering into the same category is the filling by a tipping ladle through a filter core, and two examples are given in Figs. 3 and 4. The filter core is a very effective means of keeping back the impurities of the metal; it requires very fluid metal, however. The use of a runner basin or a filter core is not recommended for alloys showing a tendency to separate out by order of density.

Bottom-Pouring Ladles.—This method of filling is shown in Fig. 5. The cleaning of the metal is effected by the floating of the slag; from this fact, it is necessary to avoid complete emptying of the contents into the mould.

Types of Runners

There are two main types of runner to be considered:—

(1) *Direct Running.*—In this case the metal falls directly and freely into the mould cavity. A simple example is shown in Fig. 6.

(2) *Interrupted Stream.*—The flow of the metal is broken before entering the mould cavity. Here several cases are illustrated varying according to the positioning of the ingates. Thus there are ingates in the upper part of the mould cavity (Fig. 7), midway (Fig. 8) and at the lowest part, usually called bottom running (Fig. 9).

It is now proposed to examine in some detail the factors which govern the different types of running used with each of the three methods of filling indicated above. In all the calculations, it is supposed that the metal to be cast is a perfect liquid, and such losses as friction, change of section and direction in the various gates will be neglected. The results given are purely theoretical. Nevertheless, they yield useful information as to the relative effects of the various methods of filling and of the different types of gating. They allow of a clearer conception of the rules of application.

It is evident that experiments carried out in certain well-defined cases, allowing of the inclusion of correction factors to apply to theoretical results, will be of value.

DIRECT RUNNING

What follows is a discussion of the use of each one of the methods of mould filling.

Direct from Tipping Ladle

The cylindrical runner M A B N in Fig. 10 is directly connected to the casting; it is surmounted by a conical opening. It receives what can be presumed to be a stream of metal circular in section, at A B the section being equal to that of the downgate. The calculations are based on this rule, which should be maintained during the whole period of teeming. The metal falls from the ladle as a free stream; its movement is uniformly accelerated, its speed increases, the input yielded by the stream being constant at all heights; its section decreases.

Supposing Se to be the section of the orifice A B; and Ve the speed of the stream across this section, and Q the input:—

$$\text{Then } Ve = \sqrt{2gH}$$

$$\text{Because } \sqrt{2g} = 4.43$$

therefore $Ve = 4.43\sqrt{H}$ metres per second. The input is therefore

$$Q = Ve \times Se = 4.43\sqrt{H} \times Se$$

Below A B the diameter of the stream continues to diminish. For the same height of drop H, the section of the opening controls the input of the downgate. The author terms this the preponderating section of the running system.

Speed of Entry of the Metal into the Mould Cavity.—This is the speed of the stream in the section M N and is of but little interest in this case. The speed of a stream in any given section *m n*, situated at a distance *h* below the orifice A B, is

$$v = 4.43\sqrt{H+h}$$

In deep moulds, this speed can become sufficiently powerful to injure the bottom, when impacted by the initial stream.

The input delivered by the stream will be

$$Q = 4.43\sqrt{H} \times Se$$

In order that the rate of filling remain constant during casting, it is necessary to keep the lip of the ladle always at the same height.

Note.—In practice, for reasons previously stated, the stream of metal is regulated so as to keep the top of the runners full; filling is therefore always carried out according to Fig. 11. It is admitted that the stream of metal is subject to eddies in the funnel, which slow up the speed of dropping without nullifying it. Breaking action by small liquid streams results in a loss of force. Supposing that in A B the loss of force is equal to *z*, then the speed Ve in A B becomes

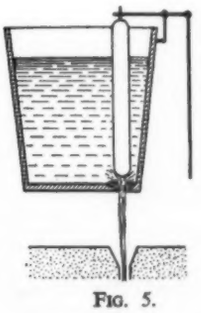


Fig. 5.

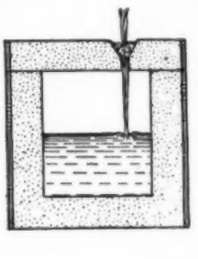


Fig. 6.

$$Ve = 4.43\sqrt{H - z}$$

and the input $Q = 4.43\sqrt{H - z} \times Se$

Below A B, the stream continues its course by a uniformly accelerated movement; its section becomes increasingly narrowed. For the section *m n*, at a distance *h* from A B, one has

$$v = 4.43\sqrt{H - z + h}$$

* Extracts from an article published in "La Fonte."

It is evidently impossible to establish the value of z other than by experiment and without being able to generalise the results obtained in each case, it can be stated, however, that the value $H - z$ cannot be less than the distance m from the top of the runner, the latter always playing the rôle of a reservoir at a constant level.

Consequent upon the loss of force due to the conical opening, the speed at A B and the quantity Q can also vary between two extremes. For example,

$$4.43\sqrt{H} > Ve > 4.43\sqrt{m}$$

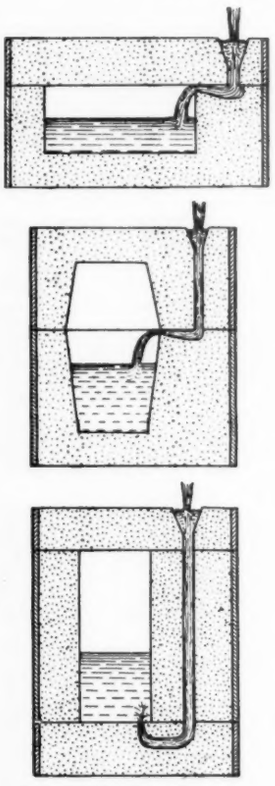
or by multiplying by Se:—

$$4.43\sqrt{H} \times Se > Q > 4.43\sqrt{m} \times Se.$$

In certain cases, the depth of the funnel of the runner can be of importance.

Filling by Tipping Ladle into a Runner Basin

This method is sketched in Fig. 12. There are several different types of runner basins for ensuring that clean metal enters the mould. The simplest form will be considered here, as the results obtained can be applied to other arrangements. The basin is fed by a tipping ladle in such a way that it is constantly full. The basin



FIGS. 7 (TOP), 8 (CENTRE), AND 9 (BOTTOM).

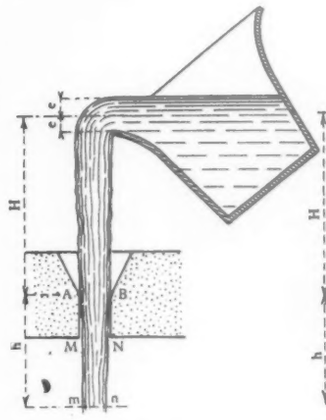


FIG. 10.

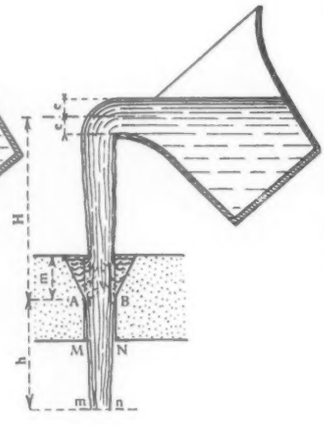


FIG. 11.

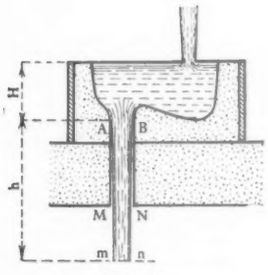


FIG. 12.

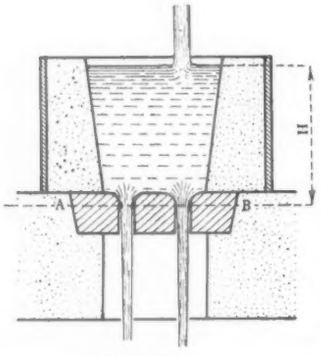


FIG. 13.

thus becomes a reservoir with a constant level. It is postulated that eddying is without any action on the flow of the metal. The diameter of the stream leaving the ladle and the drop are no longer important; only quantity matters. The metal flows by the cylindrical downgate M A B N. The section A B is taken at the neck of the hole joining the downgate to the basin. This round hole is of some importance. If the downgate is allowed to terminate at a right angle in the basin, it will produce a contraction in the liquid stream which can attain $\frac{4}{10}$ of its section. Sometimes it is unnecessary to seek elsewhere for the cause of a casting which is short-run, when these conditions exist. The stream of the metal fills the whole of the orifice A B and then becomes less than the diameter. Once again, it is the section of this orifice that is the *preponderating section* of the gating system. Continuing to use Se to designate the section of the orifice A B, Ve the speed of the stream at the edge of the stream, and Q the input, then

$$Ve = 4.43\sqrt{H}$$

$$Q = Se \times Ve = 4.43\sqrt{H} \times Se$$

Speed of Entry of the Metal into the Mould Cavity.—As in the preceding case, this is of little interest. The speed of flow in the section $m\,n$ is

$$v = 4.43\sqrt{H + h}$$

Input of the Gating System.—In the same section of entry Se, the quantity is proportional to the square root of the distance H from the level of the basin above the section of entry. Where two basins are used having the same gate section with different distances H_1 and H_2, the following result is given:—

$$\frac{Q_1}{Q_2} = \frac{4.43 \times Se \times \sqrt{H_1}}{4.43 \times Se \times \sqrt{H_2}} = \frac{\sqrt{H_1}}{\sqrt{H_2}}$$

If, for example, $H_1 = 2H_2$, then

$$\frac{Q_1}{Q_2} = \frac{\sqrt{2}}{1} = 1.414.$$

By doubling the distance H, the input is increased by about 40 per cent. In practice the influence of this distance on input is often but little appreciated.

Filter Cores.—As has previously been pointed out, the above results are applicable to gates carrying filters, the funnel of the gate being considered as a reservoir of constant level. An example is shown in Fig. 13. The openings of the filter are shown with rounded holes on the upper surface. In this case, the distance H is taken from the base of the rounded portion. The section of entry Se is the sum of the sections of the holes in the filter and gives—

$$Ve = 4.43\sqrt{H}$$

$$Q = 4.43\sqrt{H} \times Se.$$

If, as often happens, the holes in the filter have their upper edges in the form of a right angle, the distance H varies but little. On the other hand, due to contraction, the section of the liquid streams diminishes. If m is the coefficient of contraction, the true section of the whole of the streams in the plane A B is

$$Se \times m$$

The preceding formulæ give:—

$$Ve = 4.43\sqrt{H}$$

$$Q = 4.43\sqrt{H} \times Se \times m$$

It seems germane to state that the coefficient m can vary between 0.6 and 1.0. Consequently the filter-core system will not be specially discussed, as it can be considered as a special kind of runner basin for which the same formulæ can be applied.

Filling with a Bottom-pouring Ladle

Fig. 14 shows the direct filling of a mould from a bottom-pouring ladle. With this system of pouring it is no longer so easy to control the section of the stream. It is assumed that as the section of the nozzle P Q is less than the section of the opening A B, the latter is never therefore filled. It is, moreover, assumed that the goose-neck arrangement allows of the reduction of the section of the liquid from the ladle, but that it has no action on the speed of the liquid streams.

In any given section the speed of the stream is that which would have a material point falling direct from the upper level of the metal in the ladle down to the plane of the section under consideration. As the liquid metal sinks in the ladle progressively with the casting up, the speed decreases in all sections of the stream. If Sp be the section of nozzle P Q; Vp and s respectively the speed and the true section of the stream across the opening; p the height of the metal above P Q on starting pouring and l the sinking of the level during the casting, the speed of the stream at P Q ranges between two limits according to the inequalities:—

$$4.43\sqrt{p} > Vp > 4.43\sqrt{p - l}$$

Theoretically two methods of casting can be envisaged:—

(1) *Casting with the section of the stream constant and the output variable.*—If Q_1 is the output at the beginning of casting and Q_2 that at the end of pouring, then

$$Q_1 = 4.43\sqrt{p} \times Sp$$

$$Q_2 = 4.43\sqrt{p - l} \times Sp$$

from which

$$Q_2 = Q_1 \times \frac{\sqrt{p - l}}{\sqrt{p}}$$

For example, if $p = 1$ metre; $l = 0.8$ metre, then

$$Q_2 = Q_1 \times 0.45.$$

The output in this case decreases by more than 50 per cent. at the end of the cast.

(2) *Casting with the section of the stream variable and the output constant.*—During casting, the section of the stream can be increased to compensate for the reduction in rate of flow. If s_1 and s_2 be the sections of the stream at the beginning and end of the cast, and the output be constant, then:—

$$4.43\sqrt{p} \times s_1 = 4.43\sqrt{p - l} \times s_2$$

hence $s_1 = s_2 \times \frac{\sqrt{p - l}}{\sqrt{p}}$ if it be assumed that the nozzle P Q remains full, one can replace s_2 by Sp in the preceding formula, giving

$$s_1 = Sp \times \frac{\sqrt{p - l}}{\sqrt{p}}$$

$$Q = 4.43\sqrt{p - l} \times Sp$$

Maintaining the same system of letters as previously for the various factors, it can be shown that:—

$$s_1 = Sp \times 0.45$$

Now for a slight lifting of the lever, the section of the stream increases rapidly, and it is

difficult to carry out casting with a constant output. Because of this it is proposed only to discuss casting with a constant stream section and a variable output.

Preponderating Section of the Casting System.—With the bottom-pouring ladle, the orifice of entry A B has no longer the same importance as previously, for in reality the nozzle section P Q becomes the preponderating section of the casting system.

Speed of Entry of the Metal into the Mould Cavity.—At the section A B, it is:—

$$4.43\sqrt{H} > Ve > 4.43\sqrt{H - l}.$$

At the section *m n*, it is

$$4.43\sqrt{H + h} > v > 4.43\sqrt{H - l + h}$$

Input of the Gate.—This is governed by the nozzle P Q. It has been shown to be a variable,

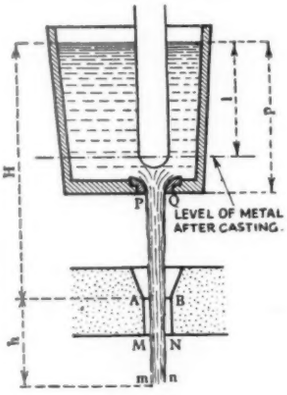


Fig. 14.

and satisfies the expression of the inequalities—

$$4.43\sqrt{p} \times Sp > Q > 4.43\sqrt{p - l} \times Sp$$

INTERRUPTED STREAMS

Considering the case where a casting is run half way up the mould cavity, then the results obtained will apply directly to top-casting. It is proposed to deal with gating at the upper level of the mould cavity and to study simultaneously the use of the three methods of filling sketched in Figs. 15 to 17. From the beginning of the casting, with I and II methods of filling (I by tipping ladle pouring directly into the downgate and II a similar ladle feeding a basin), the stream exactly fills the orifice A B, which gives in this orifice

$$Ve = 4.43\sqrt{H}$$

$$Q = 4.43\sqrt{H} \times Se$$

With the third method of pouring III (by means of a bottom-pouring ladle), the stream fills the nozzle P Q and gives:—

$$Vp = 4.43\sqrt{p}$$

$$Q = 4.43\sqrt{p} \times Sp$$

The metal in falling meets the bottom of the downgate, collects there and starts to flow into the mould cavity of the casting by the ingate M N. Assuming that the speed of the stream is completely interrupted on arrival at the bottom of the downgate, then taking the moment when the level of the metal in the downgate is at *a b*, and supposing h^1 to be the distance from the centre of gravity of the section M N in the plane *a b*, Sa the section of the ingate M N, Va the speed of flow in this section and Qa the input, this gives

$$Va = 4.43\sqrt{h^1}$$

$$Qa = 4.43\sqrt{h^1} \times Sa$$

At this moment, two widely different cases can be envisaged:—

(1) *The section of the ingate Sa is notably greater than the section of entry Se.* The input Qa is equal to the input Q for a low value of h^1; this represents casting under subnormal pressure.

(2) *The section of the ingate Sa is notably smaller than the section of entry Se.* The input Qa becomes less than the input Q; the downgate becomes full. The flow from the section M N is made under a force equal to the distance from its centre of gravity to the top edge of the downgate. This represents casting under pressure.

Subnormal-Pressure Casting

Ingate Halfway up the Mould Cavity.—This is assumed to be the case for Figs. 15 to 17.

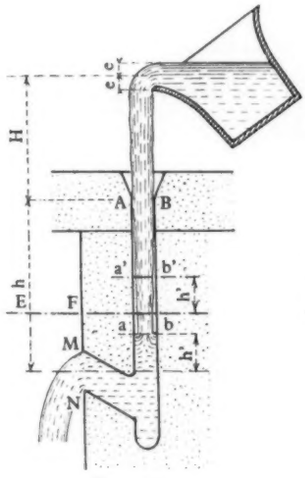


Fig. 15.

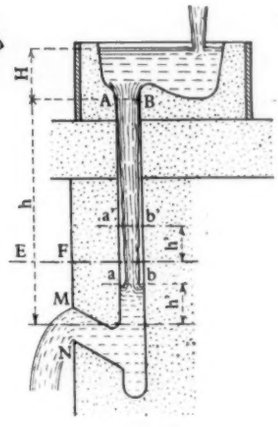


Fig. 16.

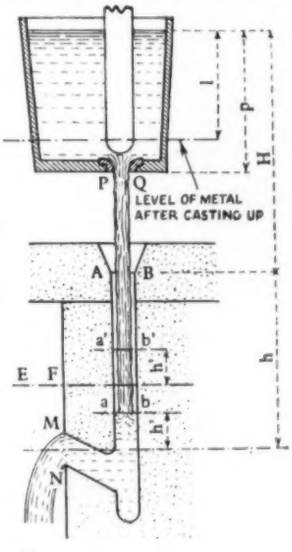


Fig. 17.

Normal conditions of casting being established, then Qa = Q and one can postulate that:—

$$Va = 4.43\sqrt{h^1}$$

$$Q = 4.43\sqrt{h^1} \times Sa$$

Speed of Entry of the Metal into the Mould Cavity.—The speed Va depends solely upon the height h^1, the latter itself depending on Sa for any given input. Thus, in subnormal pressure casting, a rate of entry of the metal into the mould cavity as low as is desired can be obtained, if the shape of the casting allows of a sufficient increase in the section of the ingate. With a bottom-pouring ladle, the input being variable, the distance h^1 and the speed Va also vary.

The above conditions persist until the moment at which the level of the metal in the mould cavity reaches the opening M N. From this time onwards the level of the metal in the downgate also rises. Assuming the metal at E F in the mould cavity, then it will reach a^1 b^1 in the downgate at a height above that of E F, which will always be equal to h^1 for the flow in the section M N is governed by the formula:—

$$Q = 4.43\sqrt{h^1} \times Sa$$

Thus the speed Va remains constant during the pouring, except when a bottom-pouring ladle is used, when it decreases.

Input from the Downgate.—This is governed by the stream in the preponderating section of the casting system. When filling with a tipping ladle, it is:—

$$Q = 4.43\sqrt{H} \times Se$$

Q is constant if H is constant. With a bottom-pouring ladle, the conditions are:—

$$4.43\sqrt{p} \times Sp > Q > 4.43\sqrt{p - l} \times Sp$$

Momentary Interruption.—The pressures in a mould at the end of casting are generally foreseen as acting upon the top edge of the downgate top or the runner basin. In the direct filling by a tipping ladle it has been assumed that the stream of metal constantly fills the point of entry A B. Now when the level of the metal in the downgate reaches this point, the force under which it affects the flow in the opening M N changes rapidly from h^1 to $H + h^1$, if the input of the stream coming from the ladle has not been reduced in the meantime.

If, at this moment, the metal in the mould cavity has already reached the top of the mould, it can produce a notable super-pressure. That is why it is sometimes noted that with certain moulds, apparently well weighted, a sudden lifting occurs at the end of casting, after which everything seems to be normal. The super-pressure can only be of very short duration, for its action stops when the stream is interrupted and the downgate overflows.

Loss of Force due to the Funnel of the Downgate.—The funnel of a downgate can be kept constantly full during direct teeming with a tipping ladle. In this case, it is necessary to take into account the loss of force *z*, previously dealt with. In the formulæ cited it is necessary to replace H by H − *z*.

(2) *Bottom Running.*—What has been said in respect to gating halfway up still applies, except for the fact that the opening M N is closed by metal from the beginning of casting.

(3) *Running at the Top Part of the Mould Cavity.*—Actually, this type of running is seldom met with in practice. Often the moulder

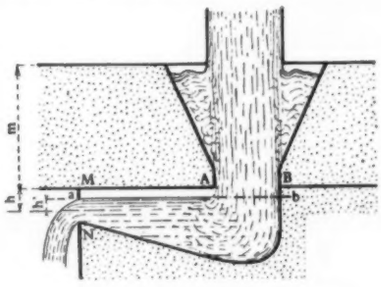


Fig. 18.

fancies he has achieved it when he has done nothing of the kind, for it is necessary to give an exaggerated section to the ingate. Referring to the sketch, Fig. 18, and regarding it in its most favourable light by assuming the loss of force due to the cone to be at a maximum, then

$$H - z = m.$$

Allowing that the level *a b* in the "downgate" leaves empty a third of the height of the opening M N, assumed to be rectangular, then taking *m* to be 16 cm., the distance M N to be

2 cm., h^1 to $\frac{2}{3}$ cm. and Se to be 4 sq. cm., by equating the inputs of the ingate and of the orifice of entry, and by neglecting h in relating to m, it clearly gives:—

$$4.43\sqrt{m} \times Se = 4.43\sqrt{h^1} \times \tfrac{2}{3} Sa$$

$$\text{or } Sa = Se \times \frac{\sqrt{m}}{\sqrt{h^1}} \times \tfrac{3}{2} = 4\frac{\sqrt{16}}{\sqrt{2/3}} \times \tfrac{3}{2} = 30 \text{ sq. cm.}$$

The height of the ingate being 2 cm., it would therefore be necessary for it to be 15 cm. long, which is in practice of rather a tall order.

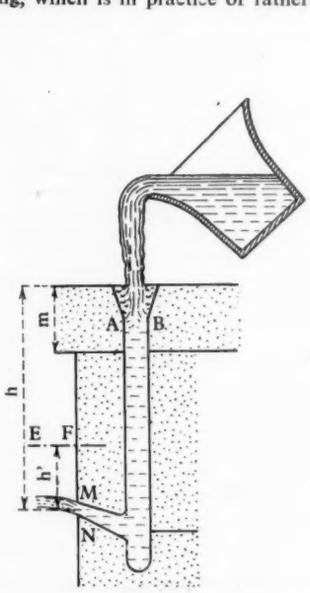


FIG. 19.

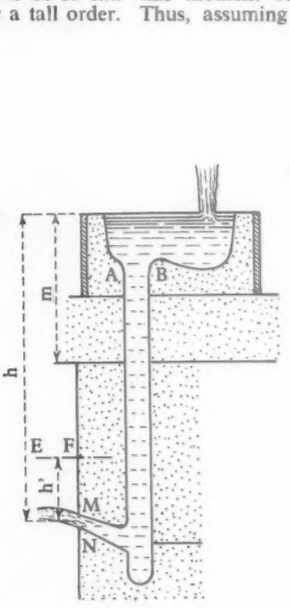


FIG. 20.

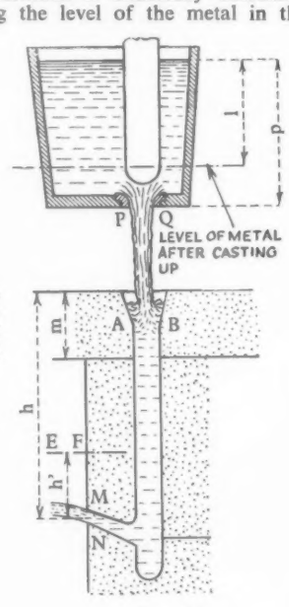


FIG. 21.

Actually, the downgate and the conical opening are constantly full; they form a reservoir of constant level in which the section A B creates a loss of force because of the narrowing which it exerts upon the liquid column.

Casting Under Pressure

(1) *Ingate Halfway up the Mould Cavity.*—At the beginning of casting, conditions are as shown in Figs. 15 to 17; the metal accumulates at the bottom of the downgate and starts to run into the mould cavity. It has been shown that the input Qa from the ingate is notably less than the input Q from the stream of the ladle. As the runner becomes full, it is necessary to lessen the input from the ladle in order to attain Qa. This state of affairs is shown diagrammatically in Figs. 19 to 21.

From now on, the downgate can be regarded as a reservoir of constant level in which the speed of arrival of the stream leaving the ladle is without influence. In the opening M N, the flow is under pressure h, which is the distance of the centre of gravity of the opening from the upper level of the metal in the runner or the basin.

Speed of Entry of the Metal into the Mould Cavity.—In the opening M N, it is

$$Va = 4.43\sqrt{h}.$$

The speed Va remains constant until the moment when the level of the metal in the mould cavity reaches the section M N. From this moment onwards it constantly decreases. Thus, assuming the level of the metal in the mould cavity E F to be at a height h^1 from the centre of gravity of the opening M N, then the speed of entry into the mould cavity becomes:

$$Va = 4.43\sqrt{h - h^1}$$

If m be the distance from the top surface of the downgate or runner cup to the lower surface of the top of the mould, from the beginning to the end of casting, then

$$4.43\sqrt{h} > Va > 4.43\sqrt{m}$$

Input of the Downgate.—When casting under pressure, the ingate governs the input and the section Sa becomes the preponderating section of the casting system.

(*a*) *With the first two systems of filling,* the input varying simultaneously with the speed of filling Va, it is:—

$$4.43\sqrt{h} \times Sa > Qa > 4.43\sqrt{m} \times Sa$$

(*b*) *With filling using a bottom-pouring ladle.* It has been assumed that no control of input is practicably possible; the downgate always remains full. It is always necessary that the input Q from the ladle is less than Qa, the maximum input of the downgate. Initially it will be:—

$$4.43\sqrt{h} \times Sa > 4.43\sqrt{p} \times Sp$$

$$\text{or } Sa > Sp\frac{\sqrt{p}}{\sqrt{h}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

and at the end

$$4.43\sqrt{m} \times Sa > 4.43\sqrt{p - l} \times Sp$$

$$\text{or } Sa > Sp\frac{\sqrt{p - l}}{\sqrt{m}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

In order to check the section Sa, it is necessary to choose from the inequalities (i) and (ii) the one which gives the higher value.

(2) *Bottom Running.*—What has been established above applies equally well to bottom running. From the start of casting, the opening M N is closed by metal; the input from thereon constantly decreases as the speed of entry of the metal in the mould cavity.

(3) *Ingate at the Top Part of the Mould Cavity.*—This is illustrated in Figs. 22 to 24. The height of the ingate is generally low in relation to the height m. As it is negligible, one can postulate:—

$$Va = 4.43\sqrt{m}$$

$$Qa = 4.43\sqrt{m} \times Sa$$

The speed Va and the input are constant during the filling of the mould cavity, under the express condition that the input from the ladle be also constant. A tipping ladle used in conjunction with a runner basin fulfills these conditions. With a bottom-pouring ladle, the input decreases with the lowering of the level of the metal in the ladle. At the beginning of casting there should be the conditions that:—

$$4.43\sqrt{m} \times Sa > 4.43\sqrt{p} \times Sp.$$

which implies that—

$$Sa > Sp\frac{\sqrt{p}}{\sqrt{m}}$$

Then the level of the metal lowers in the runner at the same time as in the ladle. Casting under pressure with an ingate at the top of the mould cavity gives a system of running which largely parallels that obtained by direct filling.

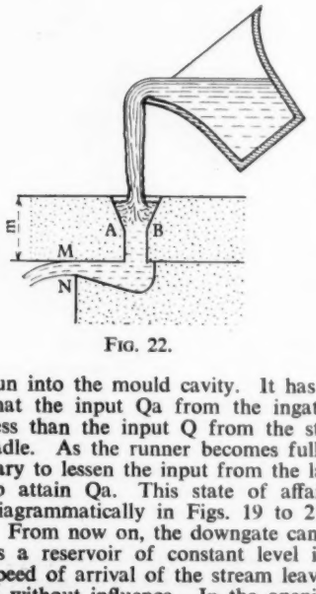


FIG. 22.

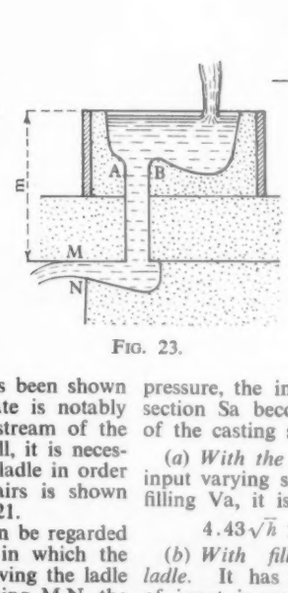


FIG. 23.

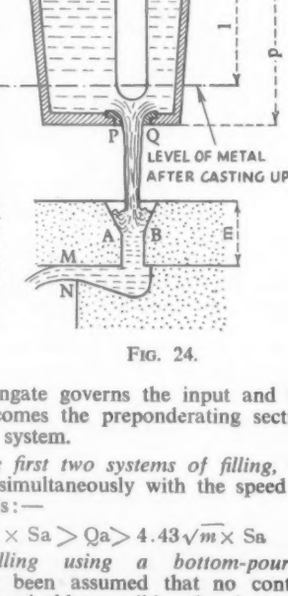


FIG. 24.

Centrifugal Casting

(*Continued from page* 236.)

before pouring removes most of those impurities, and provided freezing of metal in the mould does not take place too quickly, the balance tends to float to the top surface of the casting by displacement in the liquid metal.

In centrifugal casting this weight differential and "floating out" tendency is multiplied many times, and impurities are literally *driven* out. Stated mathematically, the ratio of the force of centrifugal separation to that of gravity separation is $\frac{4^2\ rn^2}{g}$ where r is the distance of the particle from the axis of rotation (in feet) and n is the number of revolutions per sec. Taking as an example a casting being made centrifugally at 1,000 r.p.m., and considering an entrapped oxide particle 4 in. from the axis of rotation, it is found that this particle is driven from the body of the casting by a force *110 times* that which would exist in a sand casting.

While the effect of this multiplied casting pressure on physical properties of the resultant casting is definitely favourable, it is not as great as might be supposed. In general, tensile and yield strengths of the metal are raised from 10 to 20 per cent., hardness remains approximately the same except on alloys affected by chill action, and elongation may drop slightly. The greatest and most important effect from the engineer's standpoint lies in the *uniformity* of the physical properties of centrifugal castings, for spinning does assure a uniformity difficult to obtain in static castings.

Porosity in Aluminium-Alloy Castings

(*Continued from page* 218.)

Mould Design

When considering the effect of mould design upon the incidence of porosity and analogous defects, it will be clear that marked differentiation should be made between sand castings, gravity die-castings, and pressure die-castings. To examine, first, the case of sand castings, problems associated with the selection of moulding sands and core sands will be considered in conjunction with those of design.

Because of their bright silver colour, aluminium alloys tend to show in an emphasised form any surface defects acquired from the mould, hence fine sands are to be preferred, for the searching powers of molten light alloys are such that a coarse sand will yield a most unsightly finish, difficult to inspect and prone to retain sand particles which will cause damage to tools during subsequent machining. Similarly, patched mould surfaces will often result in unsightly scabbing.

Sand

Owing to the fact that fine sand is, for the above reasons, to be preferred, and because of

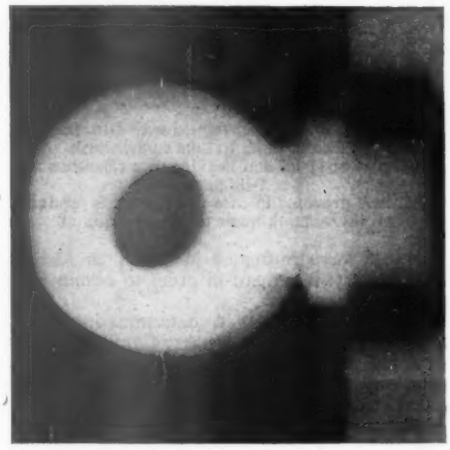


Fig. 3.—Radiograph showing Porosity due to Inadequate Feeding of a Light-alloy Sand Casting.

the low gas-displacing powers of light alloys (due, as previously mentioned, to their low specific gravity), great care must be taken that sand moulds for aluminium alloys are not too heavily rammed, otherwise a potential source of blowholes is obviously created. Moulders with experience chiefly confined to steel castings frequently tend to this fault; those practised in iron casting are less likely to commit the error.

Green-sand moulding is practically universal, but because of the tendency of the metal to react with steam, and to avoid generally the production of excessive amounts of vapour in the mould, the use of wet sand should be avoided.

The use of unyielding cores or excessive ramming in the case of certain intricate castings may result in hot tearing or cracking owing to the greater or less degree of hot-shortness associated with most aluminium alloys. Inadequate ventilation of cores will lead to core blow.

As regards mould design and its influence upon porosity and casting defects generally, gating requires careful attention in order that turbulence may be avoided, otherwise dross inclusions are likely to be formed in the casting. Insufficient feeding of heavy sections will tend to result in draws, particularly at the junction of light and massive sections.

Chills are also sometimes recommended to control the rate of solidification of the massive section deemed responsible for the trouble, but unless used with the greatest of care they may cause other difficulties, particularly if they are used in the uncoated state, when they are likely to occasion the condensation of moisture which is vaporised by the hot charge, thereby giving rise to opportunity for gas absorption and subsequent porosity in the casting.

Again, few general rules can be laid down for mould design. Each type of casting must be examined on its own merits, and a satisfactory procedure established by adequate trial before production is undertaken. In this way, the mechanical difficulties mentioned can usually be overcome.

Design of Permanent Moulds

Gravity die-castings introduce fewer difficulties of porosity than sand castings, but special attention must be paid to the design of the die and cores as, being in a perfectly rigid material, cracking of the casting is liable to occur unless shrinkage stresses are adequately compensated for by the use of chills, and by carefully designed and located gates. Adjustment of permanent moulds is both more difficult and more expensive than the rectification of sand moulds. All available experience should be co-opted before the manufacture of a die be undertaken, as the subsequent occurrence of faults which result from incorrect mould design may be a serious matter in the case of massive castings.

The coring of gravity dies presents certain points worthy of interest in connection with the present problem. Cores must be vented for the same reason that sand moulds are vented, namely, to permit the ready displacement of the air contained in the mould; blowholes will occur if inadequate measures be taken.

To facilitate their ready withdrawal, cylindrical cores in permanent moulds must commonly be tapered and for many reasons the taper allowed should be as generous as possible. But instances may arise where it is desired to reduce the taper to the minimum. In the latter case, special attention should be paid to the dressing of the core with one or other of the standard mixtures designed to protect the core material from attack by the charge, also to the careful control of core temperature, otherwise difficulty may be found in withdrawing it, with the result that scruffing of the surface of the casting may occur.

Dies for Pressure Die-Casting

Reference has already been made to the porosity which sometimes occurs in the interior of pressure die-castings, and to the fact that the rapid chilling of the outer skin effectually inhibits any tendency to visible external porosity. The metal enters the die at a very high speed, hence the design and location of the runner-gate (or gates, in the case of a multiple die) must be such as to avoid air locks and excessive turbulence which would lead to serious porosity (as opposed to the usually entirely unimportant type already referred to).

Furthermore, the die must be vented to allow the air it contains to escape before the advancing metal, whilst at the same time, the rate of venting must be so controlled that a "cushion" is provided to protect the face of the die opposite the sprue from the erosion effects of the high-pressure stream of molten alloy. A gap of 0.002 to 0.003 in. at the parting line is usually allowed for the purpose, such a vent being too small to permit the escape of metal.

The foregoing account will have made clear that avoidance of porosity and inclusion difficulties in foundry practice depends partly on the strict observance of a number of well-defined routine precautions, and also on the intelligent modification of established principles to cater for the specific requirements of particular alloys and particular designs.

Careful consideration will show that, whereas the sand casting and the mould in which it is produced make great demands upon the skill of the foundryman and moulder at every stage of their evolution, the use of the gravity-die or permanent mould calls for a lesser degree of

Fig. 4.—Radiograph showing Porosity in an Alpax Sand Casting. It is pronounced in the Heavy Sections.

aptitude on the part of the caster. On the other hand, the operation of a pressure die-casting plant demands less skill on the part of the operator, although none the less in scientific and technical control.

Means for Eliminating Recurrent Defects

Optimal conditions in the case of sand castings must be determined for virtually every alloy group and for every variation in size or design of casting. In this connection, X-ray examination in conjunction with the recognised mechanical and fracture tests has proved invaluable, and, indeed, successful mould design, design of casting and pouring conditions, etc., have been evolved on the basis of repeated inspection of castings produced by techniques modified progressively in the light of the results of such examinations until, finally, the desired degree of perfection has been attained.

Similarly, although less readily, defects in gravity die-castings may be eliminated step by step until a perfect result is obtained. Pressure die-castings constitute a special case, the care of which must be left largely in the hands of the die manufacturer.

The entire elimination of porosity in light-alloy castings (or, for that matter, in castings in any heavy-metal alloy) has not yet been attained as an established general practice. In given castings, its significance must be assessed in terms of the use to be made of the casting, whether it is required to be pressure-tight, for example, or to possess especially high mechanical strength. Not only the type of porosity, but also its location, size of individual pores, and distribution, are of importance in these connections. Tests for porosity will first include visual examination of the exterior surface of the casting, followed by the examination of the nature of fractures at selected points in order to determine the presence of internal porosity. Further tests may be necessary, depending upon the use to which the casting is to be put.

To determine resistance to seepage under low hydrostatic pressures, the interior of the casting may be filled with petrol, paraffin or methylated spirit (all of which have great penetrative powers) dyed with some vivid aniline colour in order to render minute leakages to the external surface more easily visible. When greater resistance to penetration is required, air or soap water at pressures of 30 to 100 lbs. per sq. in. may be used, freedom from porosity being determined directly (*i.e.*, by leakage of water, or by "bubbling") or by the absence of pressure drop after an appropriate interval.

Cast plates or similar flat forms which cannot be conveniently filled with the testing liquid may be used, in conjunction with suitable gaskets, to close the ends of tubes to which they are clamped, the tube being then filled with the liquid, and the test carried out in the usual way.

It may not be inappropriate here to mention the precaution which must be taken in high-pressure testing, say of the order of 1,000 lbs. per sq. in. Under air pressure, rupture of the casting may result in fragments of metal being scattered over a wide area. With water at the same pressure, the danger appears to be less, as warning is usually given by preliminary leaking and, in any case, the fragments of metal are not projected so violently.

Paraffin, petrol and methylated spirit should not be used for high-pressure tests where the source of pressure consists in the direct application of compressed air to the liquid. Under such conditions these liquids tend to detonate, and serious damage may well be caused.

Improved casting alloys and the introduction of modern foundry technique have done much to diminish the frequency and extent of the defects discussed and, with these advances, the field of utilisation of castings is continually broadening. Already, as has been noted, it is encroaching upon regions which were once deemed the prerogative of wrought alloys and still further progress is promised in the near future.

Elasto-Resistance Changes in Nickel-Iron Alloys

The change of electric resistance caused by tension was observed in nickel, iron and nine kinds of nickel-iron alloys, in investigations carried out by NORIE YAMANAKA and described in a Paper in "Science Reports of Tohoku Imperial University." In all these materials, the resistance change of the magnetic origin increases or decreases with the tension, according as the magnetic elongation is positive or negative. The maximum value of that change, attained by the tension extending to the elastic limit, is closely connected with the saturation value of the magneto-resistance in each of the materials.

Elimination of Boxes in the Steel Foundry

By A. J. HUMPAGE

Small or medium-sized work in the steel foundry calls for a quantity of box parts, and as a result valuable space is wasted, whilst ramming time is increased. The author suggests that the box shown in Fig. 1 can be of valuable service. Any depth or width of box can be made. If top-part boxes are really needed, any design of bar could be cast in this type of box.

The box is made open end with right-hand and left-hand runner holes, and if cast in steel the oxy-acetylene burner can be used to make holes for taking prods, bars or grids at will. Boxes should be machined on the face, and all pin-holes set to jig. Plates (Fig. 2) are also designed to be of several uses. It is suggested that if plates are used upon which to build cores for larger castings they should be cast without lugs. A good plan is to cast some with and some without lugs.

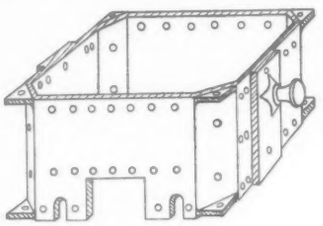
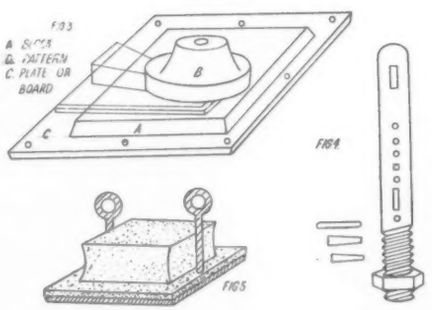


FIG. 1



The boxes and plates being ready, the pattern is rammed up from a block (A, Fig. 3). Any width or depth of block will serve so long as it leaves sand clearance inside the box. The box is set on a board or plate, and heads and runner are placed as desired. Then ram up the box, place a plate over it, make fast and roll over; the block (A, Fig. 3) is then removed, the pins are set (Fig. 4), and the joint is made in the ordinary way. The job is rammed to the level of the box, and another plate—the lug plate—is put in. Roll back again, remove the plate, extract the head-block, etc., lift out the pattern in the drag part, and finish. Multiple casting can be practised with success with this design of box.

The casting shown is cast open end, and a plate used instead of a board. The box pins are designed to take long or short lifts. The round pin is placed in any of the round holes, and screwed up just sufficiently to tighten it for inserting the locating pins. When closing the box for casting, the nut and one or two cotter pins (not nuts) come into use. The pin can be worked upside down if required, and can be taken out at will. If removed after casting it avoids any damage to the pins. The plate when used as a core plate (Fig. 5) in any mould is set in a deep print, and enough sand is allowed to come flush with the bottom of the mould. If a plate is the size of the print on the pattern, the use of sand as shown (Fig. 5) need not be entertained.

Structure and Properties of Copper Powder Compacts

DR. C. G. GOETZEL, in a Paper which he prepared for presentation to the Institute of Metals, has summarised the results of his research in the following terms:—

Copper specimens were made from metal powders, which were consolidated by pressure in a steel mould under heavy load, and the resulting compact then heated to a temperature below the melting point of the material; or by compressing the powder in a heated mould so that both of these operations were carried out simultaneously. In some cases the compacts so produced were re-treated in a manner identical with the first treatment in order to obtain better physical properties.

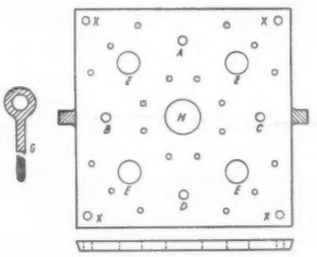


FIG. 2.

A, B, C & D are holes tapped with 1-in. thread.
E indicates holes to take runner bush.
X, holes of 1¼-in. dia. (leaving nice clearance for 1-in. pins.
H, hole provided in case sweep work is needed.
G, lifting hook made to length required.

The study includes a determination of the effect of the following factors: Compacting pressure and temperature, sintering time and temperature, heat-treating atmosphere, and subsequent working or re-pressing and annealing. Hardness, impact, fatigue, malleability, and tension tests were carried out on the compacts, as well as a microscopic examination of their structure and density and conductivity determinations.

The results of such tests show that high compacting pressures give the highest density and the best physical properties; this is also true of recompression applied to sintered compacts. The closer the sintering temperature approaches the melting point of the material, the better will be the physical properties of the compact. The longer the time of sintering, the lower is the temperature needed for a given strength and *vice versa*. Vacuum-sintered compacts are much more ductile than hydrogen-sintered compacts.

Fatigue tests show that, despite the numerous cavities, porous sintered compacts show a fatigue strength about as high as that of cast metal. This is of particular significance, since it would not be expected from the usually accepted theories of fatigue failure.

The compacts moulded at high temperature are found to have a very high density and to be harder than cast copper, even though the time at the high temperature is very short and there is no grain growth and very little recrystallisation, as shown by the photomicrographs. This definitely disproves the older belief that it is necessary to achieve a crystalline structure resembling that of ordinary copper before satisfactory strength, ductility, and malleability can be secured. This points the way for entirely new developments in the field of powder metallurgy.

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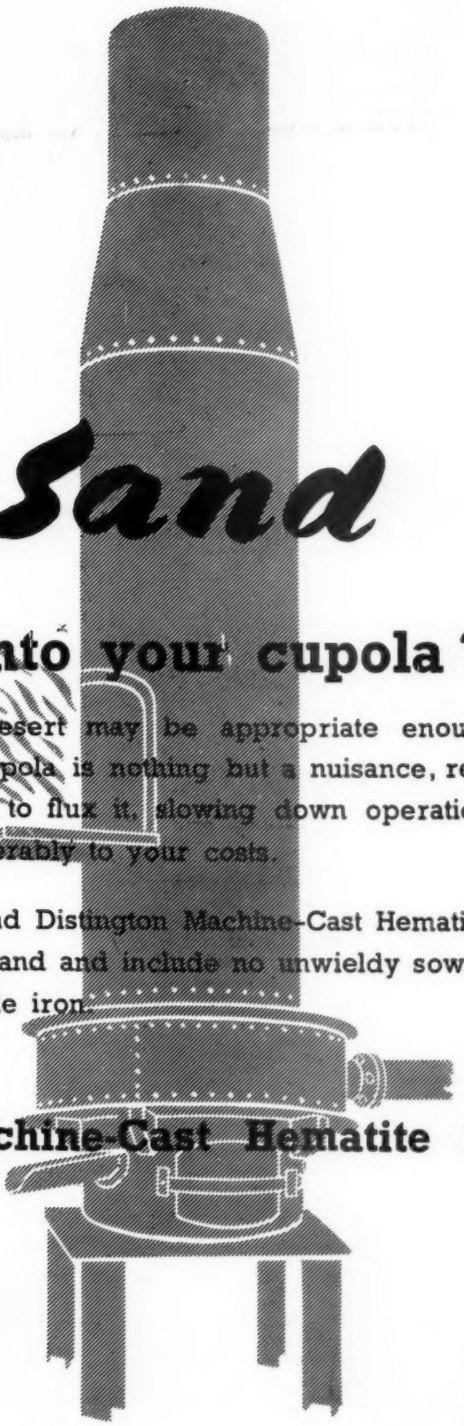

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W.53

The Week's News in Brief

Trade Talk

AS A WAR EMERGENCY MEASURE, the Central Electricity Board has been given power to generate electricity.

EMPLOYEES of J. Blakeborough & Sons, Limited, valve manufacturers, of Brighouse, have presented a motor tea-car to the Y.M.C.A. for service to the Forces.

THE FANS AND ANCILLARY EQUIPMENT EXPORT GROUP has been formed. The secretary is Mr. Arthur G. Marshall, 2, Howard Street, Strand, London, W.C.2.

HIGGS MOTORS, LIMITED, have transferred their London office from Southampton Street, W.C.2, to 6, Coppice Walk, Totteridge, London, N.20. The telephone number is Hillside 4497.

ADDRESSING the National Defence Public Interests Committee in London last week, Mr. Hugh Dalton, M.P., Minister of Economic Warfare, said that in the first year of the war the blockade had achieved remarkable success. Germany and, still more, Italy were seriously deficient in many of the key commodities, without which modern war cannot be carried on, including oil, ferro-alloys, rubber, lead and copper.

A TOO sudden removal of Government control in the steel industry might produce chaos, said Mr. W. W. Wood when he was installed Master Cutler of Sheffield for the second time. He held the positon in 1924-25. Mr. Wood said that some liaison between the steel trade and the Government would probably always be necessary, and provided those in authority understood the trade that might be all to the good. At the same time, he said, they should aim at strengthening their own domestic associations and, when peace came, at the gradual elimination of anything savouring of bureaucracy.

OF INTEREST to non-ferrous foundrymen is a new proprietary material known as "Sulfatate." It has for its object the production of a better skin on castings. Ordinary baked cores are stated to be improved by dipping them in a mixture made up of 1 pint of molasses, 10 lbs. of graphite, 1 lb. of Sulfatate and water sufficient to make up to 5 galls. The cores are then rebaked. The material is manufactured by Glyco Products Company, Incorporated, of 148, Lafayette Street, New York City. This concern is represented in the United Kingdom by Rex Campbell & Company, Limited, of 7, Idol Lane, Eastcheap, London, E.C.3.

A UTILITY car for the conveyance of works executives has been added to the fleet of producer-gas driven vehicles converted and operated by the Northern Aluminium Company, Limited. Intended for transport between the company's three works, the vehicle is required to undertake single journeys ranging from a minimum of 45 miles to a maximum of 100 miles. The conditions are therefore extremely favourable for producer-gas operation. The producer is accommodated in a compartment in the rear of the body, the difficulty of dissipating waste heat from a confined space having been overcome by the provision of specially designed ventilation.

SINCE the "Railings for Scrap" campaign was inaugurated in May, 424 local authorities have contributed 22,000 tons of best-quality wrought- and cast-iron scrap to the steelworks. In addition, 547 Councils are now surveying all available railings on their property, or are considering reports of surveys in committee. This average of 1,000 tons per week has been practically all obtained from properties owned by the local authorities, but at Bolton, Oxford, Glasgow, Newcastle and a number of other places privately-owned railings have been contributed. Both H.M. Office of Works and Liverpool Corporation have contributed over 1,000 tons, and Birkenhead, Birmingham, Bolton, Manchester and Oxford over 600 tons each. In Manchester a profit of £896 has been made from the sale of railings from 25 parks, and in Harrogate nearly 50 tons were sold, giving a profit of £138. It is intended to start a special drive for the collection by local authorities of private railings in their areas.

IN ORDER to ensure the continuance of the fullest co-operation of scientific workers with the Government in the national war effort, the Lord President of the Council, after discussion with the Royal Society, has appointed a Scientific Advisory Committee with a secretary from the Cabinet Secretariat. The members are:—Lord Hankey (chairman); Sir William Bragg, President of the Royal Society; Dr. E. V. Appleton, secretary, Department of Scientific and Industrial Research; Sir Edward Mellanby; Prof. A. V. Hill; Sir Edwin Butler; and Prof. A. C. Egerton. The terms of reference are: To advise the Lord President on any scientific problem referred to them; to advise Government Departments on the selection of individuals for particular lines of scientific inquiry or for membership of committees on which scientists are required; and to bring to the notice of the Lord President promising new scientific or technical developments which may be of importance to the war effort.

A TREASURY ORDER under Section 18 of the Finance (No. 2) Act, 1940, fixes October 21 as the date on which the Purchase Tax comes into operation. The Order, which will be submitted to Parliament for approval in accordance with the provisions of the Act, is published by H.M. Stationery Office as Statutory Rules and Orders, 1940, No. 1771. All goods chargeable with Purchase Tax which are delivered under chargeable purchases on and after that date are subject to the tax. In view of the difficulties experienced by traders, the Commissioners of Customs and Excise are still prepared to accept applications for registration. Manufacturers and wholesale merchants who are liable to registration but have not yet registered are urged to do so forthwith. Attention has already been drawn in the Press to the fact that continued failure to register involves penalties and does not free registrable businesses from liability to pay the tax as from October 21. The Commissioners of Customs and Excise have prepared a further Notice (No. 77) dealing with accounting procedure and returns and other administrative arrangements necessary in connection with the Purchase Tax. A copy of this Notice (like the official lists issued a few days ago of goods liable to the tax) will be sent to every firm registered under the Act. Further copies may be had on application to the local Officer of Customs and Excise or to the Custom House, London, E.C.3.

Personal

MR. JOHN SHAW, the well-known foundry consultant, has retired into the country. His address is now Ballramsley, Halterworth Lane, Whitenap, near Romsey, Hants.

MR. D. W. SINCLAIR, secretary and director of Rankin & Blackmore, Limited, Eagle Foundry, Greenock, has been presented by his colleagues with a canteen of cutlery and other gifts on the completion of 50 years' service with the firm.

MR. J. SCHOLES has retired after 21 years' service as chief engineer of the Consett Iron Company, Limited, including the collieries and coke-oven plant. He has been the recipient of a presentation from the officials and staff. Mr. Scholes is succeeded by Mr. J. L. Adamson.

MR. R. W. KENYON, director of Entwisle & Kenyon, Limited, Accrington, and a Past-President of the Lancashire Branch of the Institute of British Foundrymen, which he joined in 1904, has just celebrated his 90th birthday. Mr. Kenyon continues to take an active part in the management of the business.

MR. M. NELSON has resigned his position with General Refractories, Limited, as technical representative, to take up a similar position with Webster & Company (Sheffield), Limited. Mr. Nelson was similarly engaged for about ten years with J. Grayson Lowood & Company, Limited, of Deepcar, prior to their amalgamation with General Refractories, Limited.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Colloidal Research Laboratories, Limited, Ling House, Dominion Street, Moorgate, London, E.C.—Capital, £100.

Aston Tubes & Sections, Limited, 38, Wainwright Street, Aston, Birmingham—Capital, £5,000. To take over the business of tube manufacturers, brass-founders and general engineers carried on by Dobbs & Son, Limited, at Birmingham.

Obituary

MR. W. HARRISON, chairman of Harrison, McGregor & Company, Limited, agricultural engineers and ironfounders, of Leigh, Lancs, has died, aged 79 years.

MR. HENRY VAUGHAN ANTHONY, a director of Henry Bath & Son, Limited, metal merchants, of London, died recently, aged 68. Mr. Anthony had been a member of the London Metal Exchange for 30 years.

THE DEATH has occurred at Newcastle-upon-Tyne of Mr. W. E. Hurford, who retired 11 years ago after more than 40 years' service with Samuel Osborn & Company, Limited, Sheffield. He was 77 years old. His apprenticeship was served with Sir W. G. Armstrong, Whitworth & Company, Limited, and he joined Osborn's at about the time of the introduction of their "mushet" steel, helping in the successful development of its use in this country and abroad.

MR. E. J. PILKINGTON, who until his retirement several years ago was sole proprietor of Pilkington's Foundry, Widnes, has died suddenly. He established this business in partnership with his father, the late Mr. Edward Pilkington, towards the end of 1890, and when his father died ten years later assumed control. He spent three years of his retirement in South Africa, where, in his earlier days, he had connections with the foundry trade in Cape Town and Durban. He was 77 years of age.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

522,985. TRAUT, R. Galvanisation of bar-shaped articles, such as steel tubes.

522,771. SUMMERHILL, G. C., and G.W.B. ELECTRIC FURNACES, LIMITED. Case-hardening processes.

523,071. DEUTSCHE GOLD UND SILBERSCHEIDEANSTALT VORM. ROESSLER. Cementation of metals and metal alloys with beryllium.

523,072. RUHRSTAHL AKT.-GES. Method of recovering zinc oxide and ferric oxide from filter dust and the like.

523,123. POLLAK, J. E. Welded steel pipe structures for aeroplanes.

523,132. ARNESEN, C. Sheet-metal can, and opening-tool therefor.

523,251. INLAND STEEL COMPANY. Austenitic steels.

523,322. REVERE COPPER & BRASS, INC. Methods of and apparatus for coating stainless steel surfaces.

523,370. RENDAN HOLDINGS, LIMITED, and BOERKEY, W. Apparatus for use in the manufacture of barbed wire.

523,435. TIGERSCHIOLD, K. M., and SAHLIN, B. I. Metallurgical reactions effected by electrical induction.

523,605. TIGERSCHIOLD, K. M. Desulphurisation of pig-iron.

523,606. AMERICAN CAN COMPANY. Method of manufacturing tinplate.

523,777. BISS, R. Rolling-mills.

Forthcoming Events

OCTOBER 12.

Manchester Association of Engineers:—Presidential address by A. C. Dean, and presentation of Constantine and Butterworth awards, at Engineers' Club, Albert Square, Manchester, at 2.30 p.m.

OCTOBER 14.

Institute of Metals (Scottish Section):—"Developments in Non-Ferrous Research." Paper by F. Hudson, at 39, Elmbank Crescent, Glasgow, at 7.30 p.m.

OCTOBER 15.

Lincolnshire Iron and Steel Institute:—Joint meeting with the Iron and Steel Institute. "Anti-Piping Compounds and their Influence on Major Segregation in Steel Ingots." Paper by Dr. E. Gregory, at Modern School, Cole Street, Scunthorpe, at 7.30 p.m.

OCTOBER 16.

Manchester Metallurgical Society:—Joint meeting with Institute of Metals. "Intergranular Corrosion." Paper by Dr. C. H. Desch, F.R.S., at Engineers' Club, Albert Square, Manchester, at 6.30 p.m.

A Refractories Industry within one organisation

The spectacular achievements of industries which use refractories tend to overshadow the remarkable development of refractory materials during recent years. Higher temperatures and increasingly severe operating conditions have long since deposed "rule-of-thumb" methods of manufacture. Research—applied by the refractories industry, by manufacturers (such as General Refractories), and by users—has developed a range of refractories which are, at least, abreast of to-day's metallurgical processes and plant design. Unrivalled supplies of raw materials—the employment in its many works of modern plant and equipment—the services of leading technicians, operating in works bearing names familiar to all users—and supported by a wealth of practical experience—enable General Refractories to operate a complete refractories industry inside one organisation. And, influencing all activities, controlling production and future development, is "G.R." Research. In modernly equipped laboratories a team of qualified chemists and engineers build into each "G.R." product that consistently uniform quality which is the basis of low operating costs and long dependable service.

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ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister.*
SILLIMANITE: Tank Blocks, Bricks and Cements.
SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

The war effort is making big demands on the resources of the foundries producing heavy castings, and there can be no slackening of activity at these works while hostilities last. Ironmakers are being called upon to ensure the supply of adequate tonnages of iron to works engaged on Government contracts, while any surplus is eagerly taken up by ordinary domestic users. Light-castings makers are sharing a little more freely in official orders, but the amount of work available for this trade continues to be restricted, and short time is prevalent in the industry. The August returns of the Board of Trade reveal gratifying increases in imports of iron ore, scrap and steel, and it is quite obvious that the plans evolved for the prosecution of a long war, if such is necessary, are already resulting in better working conditions in the iron and steel industries.

Pig-Iron

MIDDLESBROUGH—There is no further news regarding a possible expansion of the output of Cleveland foundry iron, and this is still only sufficient to meet a very small proportion of the foundry-iron requirements of local consumers, who are, however, able to draw on the resources of the Midlands. Large deliveries are being railed each week, and, on the whole, users are supplied satisfactorily. Most buyers have now entered into contracts to ensure full deliveries up to the end of the year under licences recently granted by the Control authorities. Owing to the pressure exerted on East Coast hematite manufacturers, further imports have had to be made. In addition to heavy demands of local users, consumers in Sheffield and the Midlands are old-established customers of the East Coast furnaces and are making large demands. In many cases these users are incorporating high-phosphorus iron in their mixtures.

LANCASHIRE—Substantial parcels of pig-iron are reaching this area week by week from the Derbyshire and Staffordshire producers, and consumption is attaining very high levels. The keenest demand is from the speciality engineers, but some other sections are not badly placed for work. The dullest section is the light-castings trade, where only a few concerns are able to operate their plant on a full-time basis. Ironfounders are taking large supplies of hematite.

MIDLANDS—There is unlikely to be any early change in the condition of light-castings founders, as their main peacetime supports, the building industry and overseas trade, are certain to be quiet departments in wartime. In any case, much of the iron which might be utilised for the satisfaction of these orders is required for more urgent needs in connection with the war effort, although there are usually adequate supplies of high-phosphorus iron to meet inquiries and shortage of iron cannot be reckoned as a factor which is precluding expansion of business. Some foundries have found relief by adapting their plant to the needs of Government departments, but this has not been general and the volume of what might be described as war work among this trade remains meagre. The position of the heavy engineering foundries is that full order-books are the rule rather than the exception, and replacement contracts are available as required. These works largely consume low-phosphorus iron and hematite, the full production of which is required. Generally, sufficient iron is delivered, but there are still cases where high-phosphorus iron is needed to complete mixtures. The Control has taken steps to improve this situation by virtue of large imports of both grades of iron and also the freer distribution of special ores. High-phosphorus iron, which is produced from home ores, is in good supply.

SCOTLAND—Heavy engineering concerns are almost universally busy, but the same cannot be said of light-castings makers, most of whom are poorly situated for work. Supplies of iron are coming to hand in sufficient tonnages to cope with current demands, but it is almost impossible to lay down stocks of any magnitude, which is desirable in view of the approach of winter and the consequent less favourable conditions for transport.

Coke

Users of foundry coke continue to take full contract deliveries, and stocks at the consuming points are mostly large and sufficient to tide over any reasonable period in the winter during which fresh supplies may be delayed. The current quotation, for delivery to Birmingham and Black Country stations. is 55s. 6d. per ton for best Durham coke.

Steel

Steelworks are running at full capacity, and the supply of raw materials has been greatly improved of late, with the result that producers are able to record gratifying outputs. Nevertheless, imports of both finished and unfinished steel are continuing, and large quantities are on order. Of particular value have been the importations of semis from the United States, which since the stoppage of Belgian supplies, have been in the ascendency. The bulk of the demands on the industry continues to emanate from various Government departments.

Scrap

Immediate anxieties on the part of consumers of iron and steel scrap have been relieved, and considerable stocks now exist at many works. This happy position is not being allowed to obscure the need for ensuring future requirements, however, and the collection of scrap is proceeding apace. In addition to home sources of supply, American scrap is being shipped to the United Kingdom as required, and larger tonnages should be available from this source following the embargo on the export of United States material to Japanese ports.

Metals

Consumption of copper in the United Kingdom tends to expand, for large tonnages are being taken up by works engaged on war contracts. Supplies are being delivered quite freely, and all priority users are receiving adequate quantities. Domestic sales of copper in September in the United States constituted a record monthly figure, being no less than 255,332 short tons.

It has been announced that the Ministry of Supply has requisitioned quantities of copper belonging to eight firms in London, Liverpool, Birmingham and Newcastle-upon-Tyne, which has been lying in warehouses and wharves. The prices to be paid for the copper are: Rough £54 a ton, fire refined £57 10s., electrolytic wire bars and ingot bars £59, and cathodes £58 10s.

Pressure is being put on the Canadian Government for the imposition of an embargo on the shipment of copper to Japan. There has been much criticism during the past few months of the shipment to Japan of half of the British Columbian output of copper, and the decision of the Japanese government to line up with the Axis powers, has brought the matter to a head.

The London tin market has been rather quiet, owing to the uncertain outlook. The attitude of Japan has been rather unsettling, while the American situation is still unstable, prices being uncertain, and the question of the establishment of a smelting industry there being still in the air.

The September issue of the Statistical Bulletin of the International Tin Research and Development Council estimates that world production of tin in August was 19,100 tons, compared with 19,900 tons for July, bringing the total production for the first eight months of the year to 144,600 tons, against 87,300 tons in the corresponding period of 1939. The consumption of tin in the United Kingdom totalled 18,496 tons in the first seven months of the year, against 12,652 tons in the corresponding period of 1939, showing an increase of 46 per cent. United States deliveries totalled 70,404 tons in the first eight months of 1940, showing an increase of 69 per cent. as compared with the deliveries of 41,570 tons in 1939. World stocks of tin, including smelters' stocks and carry-over, increased by 2,402 tons during August to 51,232 tons at the end of the month. Stocks at the end of August, 1939, were 34,608 tons.

Mr. W. H. Gartsen (Henry Rogers, Sons & Company) states that the total visible supply of tin on September 30 was 34,498 tons, against 32,250 tons at the end of August. The carry-over in the Straits Settlements was 2,262 (2,172) tons, and at principal European smelters 2,611 (3,449) tons.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £255 10s. to £255 15s.; Friday, £255 15s. to £256; Monday, £256 10s. to £256 15s.; Tuesday, £257 10s. to £258.

Three Months—Thursday, £259 15s. to £260; Friday, £260 to £260 5s.; Monday, £260 5s. to £260 10s.; Tuesday, £259 15s. to £260 5s.

The spelter position remains very satisfactory. Large tonnages are, of course, passing into consumption under the requirements of Government departments, but ordinary domestic consumers are able to obtain useful supplies for the home and export markets. More than adequate supplies of lead are to be had, but demand, while quite brisk from priority users, is not outstanding, owing to the quietness of the building trade.

New business in non-ferrous scrap is still on the dull side, and works are calling for only moderate tonnages. It was expected that refineries would have taken up much larger quantities than is the case, and the tone of the scrap trade generally is disappointing.

Metal market circles are proud that one of their number, Capt. the Hon. Oliver Lyttelton, has received an important position in the Government as a result of last week's reshuffle in the Cabinet. Capt. Lyttelton becomes President of the Board of Trade, and a Privy Councillor, thus leaving open the position of Controller of Non-ferrous Metals. Up to the outbreak of war he was managing director of the British Metal Corporation, Limited, and on the board of many other metal concerns.

Reports and Dividends

Hopkinsons, Limited—Interim dividend of 5 per cent. on the ordinary shares.

Vickers, Limited—Interim dividend of 4 per cent., less tax, on the ordinary stock.

Churchill Machine Tool Company, Limited—Interim dividend of 15 per cent.

Kay & Company (Engineers), Limited—Net profit, £21,503; dividend of 12½ per cent.

Watford Electric & Manufacturing Company, Limited—Interim dividend of 5 per cent.

Thos. Firth & John Brown, Limited—Ordinary interim dividend of 6 per cent., tax free.

Ferranti, Limited—Net profit for the year to June 30, £78,158; ordinary dividend of 6 per cent., tax free.

Parkinson Stove Company, Limited—Payment of the dividend on the 7 per cent. cumulative preference shares is deferred.

Irish Steel, Limited—Net profit for the seven months ended March 31 last of £6,082, of which £5,842 is applied to depreciation.

British Piston Ring Company, Limited—Final dividend of 15 per cent. on the ordinary shares, making 20 per cent. for the year to July 31.

R. & W. Hawthorn, Leslie & Company, Limited Final dividend of 7 per cent., making 10 per cent. for the year ended June 30 last, together with a bonus of 2½ per cent., tax free.

George Wilson Gas Meters, Limited—Net profit for the nine months to March 31, £10,285; brought in, £12,567; to investment reserve, £1,500; tax, £6,500; general reserve, £10,000; no ordinary dividend; carried forward, £3,597.

Richard Thomas & Company, Limited—Consideration of the payment of a dividend on the preference shares in respect of the year ending March 31, 1941, will be deferred until the profits of that year have been ascertained.

Braithwaite & Company, Engineers, Limited—Net profit for the year to March 31 last, including a dividend from Braithwaite & Company (India), Limited, and after providing for the estimated liability for taxes, £25,493; to general reserve, £9,966; final dividend of 3 per cent. on the ordinary shares (making 5 per cent. for the year); carried forward, after preference dividend, £29,994.

ALUMINIUM ALLOYS

—for all modern requirements

Everyday sees some new development in the production of Aluminium Alloys . . . . . Everyday finds this Company ready to meet, efficiently and promptly, the most difficult demands of the moment. Whatever the specific characteristics of your requirements may be you can always rely upon International Alloys Ltd. to produce Aluminium Alloys that conform to the most exacting specification.

INTERNATIONAL ALLOYS LTD

SLOUGH, BUCKS

TELEGRAMS: INTALLOYD, SLOUGH ◆ TELEPHONE: SLOUGH 23212

RAW MATERIALS—PRICE LIST

Wednesday, October 9, 1940

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined ..	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent. ..	60	10	0
Black hot-rolled wire rods..	65	10	0

TIN

Standard cash (closing price October 8)	257	10	0
Three months (closing price October 8)	259	15	0
Settlement (closing price October 8)	258	0	0
Official average Cash, Sept.	251	6	10$\frac{6}{7}$
Do. Three Months, Sept.	254	4	7$\frac{5}{7}$
Do. Settlement, Sept. ..	251	7	4$\frac{4}{7}$

SPELTER*

G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
" Prime Western " ..	26	10	0
Refined and electrolytic ..	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b. ..	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b. ..	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works..	39	2	6
Rolled zinc (boiler plates), ex works..	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises ..	28	7	6

ANTIMONY

English, 90%, delivered ..	90 0 0
Foreign Regulus, duty paid ..	90 0 0 to 93 0 0
Chinese, prompt shipment, c.i.f. ..	79 0 0 to 82 0 0

QUICKSILVER

Quicksilver, ex-w'hse London 50 0 0 to 54 10 0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.
Finished bars, 22% tungsten	4s. 4d.

Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising ..	9d. to 1/3
Rolled—	
To 9 in. wide ..	1/3 to 1/9
To 12 in. wide ..	1/3$\frac{1}{2}$ to 1/9$\frac{1}{2}$
To 15 in. wide ..	1/3$\frac{1}{2}$ to 1/9$\frac{1}{2}$
To 18 in. wide ..	1/4 to 1/10
To 21 in. wide ..	1/4$\frac{1}{2}$ to 1/10$\frac{1}{2}$
To 25 in. wide ..	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5$\frac{1}{2}$
Ingots rolled to spoon size	1/- to 1/8$\frac{1}{2}$
Wire round—	
to 10g.	1/6$\frac{1}{2}$ to 2/1$\frac{1}{2}$

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/5$\frac{1}{2}$ upwards.

* Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal.)

	£	s.	d.
Ferro-silicon—			
25%	18	10	0
45/50%	21	10	0
75%	31	0	0
Ferro-vanadium—			
35/50%	15/6 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free ..	6/- lb. Mo.		
Ferro-titanium—			
20/25% carbon-free ..	1/9 lb.		
Ferro-tungsten—			
80/85%	5/1 lb		
Tungsten metal powder—			
98/99%	5/2$\frac{1}{2}$ lb.		
Ferro-chrome—			
2/4% car.	—		
4/6% car.	47	0	0
6/8% car.	47	0	0
8/10% car.	—		
Ferro-chrome—			
Max. 2% car.	—		
Max. 1% car.	—		
Max. 0.5% car... ..	—		
70% carbon-free ..	—		
Nickel—99.5/100%	£190 to £195		
" F " nickel shot	175	0	0
Ferro-cobalt, 98/99% ..	8/9 lb.		
Metallic chromium—			
96/98%	3/9 lb.		
Ferro-manganese—			
76/80% loose	18	0	0
76/80% packed	19	10	0
Metallic manganese—			
94/96% carbon-free ..	1/9 lb.		

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£	s.	d.	£	s.	d.
SOUTH WALES—						
Short heavy steel, not ex. 24-in. lengths ..	3	16	6	to 3	19	0
Heavy machinery cast iron		4	6	6		
Ordinary heavy cast iron		4	1	6		
Cast-iron railway chairs		4	6	6		
Medium cast iron ..		3	17	9		
Light cast iron		3	13	0		
MIDDLESBROUGH—						
Short heavy steel	3	14		to 3	16	9
Heavy machinery cast iron		4	11	3		
Ordinary heavy cast iron		4	8	9		
Cast-iron railway chairs		4	8	9		
Medium cast iron ..		3	19	0		
Light cast iron		3	14	0		
BIRMINGHAM DISTRICT—						
Short heavy steel	3	9		to 3	11	9
Hematite ingot mould		5	10	9		
Heavy machinery cast iron		4	11	9		
Ordinary heavy cast iron		4	7	0		
Cast-iron railway chairs		4	7	0		
Medium cast iron ..		3	19	9		
Light cast iron		3	14	9		
SCOTLAND—						
Short heavy steel	3	14	0	to 3	16	6
Heavy machinery cast iron		4	13	9		
Ordinary heavy cast iron		4	8	9		
Cast-iron railway chairs		4	13	9		
Medium cast iron ..		3	16	9		
Light cast iron		3	11	9		

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2$\frac{1}{2}$ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra.

PIG-IRON*

N.E. COAST (d/d Tees-side area)—	
Foundry No. 1	123/-
" No. 3	120/-
" No. 4	119/-
Forge No. 4	119/-
Hematite No. 1	131/-
Hematite M/Nos.	130/6
N.W. COAST—	
Hem. M/Nos. d/d Glasgow	131/-
" d/d Birmingham ..	142/6
MIDLANDS (d/d Birmingham dist.)—	
Staffs No. 4 forge	121/-
" No. 3 fdry.	122/-
Northants forge	118/6
" fdry. No. 3 ..	119/6
" fdry. No. 1 ..	122/6
Derbyshire forge	121/-
" fdry. No. 3 ..	122/-
" fdry. No. 1 ..	125/-
Phosphorus 0.5% to 0.75%	129/6
Phosphorus 0.1% to 0.5%	132/6
SCOTLAND—	
Foundry No. 1, Grangemouth	119/9
" No. 3, Grangemouth	117/3
Cleveland No. 3, Glasgow	123/-
" " Falkirk ..	120/-
Scottish hem. M/Nos. d/d..	131/-
SHEFFIELD (d/d district)—	
Derby forge	118/6
" fdry. No. 3 ..	119/6
Lincs forge	118/6
" fdry. No. 3 ..	119/6
W.C. hematite	136/6
LANCASHIRE (d/d eq. Man.)—	
Derby fdry. No. 3 ..	125/-
Staffs fdry. No. 3	125/-
Northants fdry. No. 3 ..	123/6
Cleveland fdry. No. 3 ..	125/-
Cylinder and Refined Irons	
North Zone..	168/-
South Zone..	170/6
Refined Malleable	
Birmingham and S. Staffs	165/6
Cold Blast	
South Staffs	217/-

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

	£	s.	d.
BASIC:			
Soft, u.t., 100-ton lots ..	10	10	0
Tested, up to 0.25% C. ..	10	15	0
Tested, 0.25 to 0.33% C.	10	17	6
Tested, 0.33 to 0.41% C...	11	0	0
Hard (0.42 to 0.60% C.)..	11	17	6
" (0.61 to 0.85% C.)..	12	7	6
" (0.86 to 0.99% C.)..	12	17	6
" (1% C. and up) ..	13	7	6
Silico-manganese	14	5	0
Free-cutting	12	10	0
SIEMENS MARTIN ACID			
Up to 0.25% C.	13	15	0
Case-hardening	14	12	6
Silico-manganese	14	10	0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C...	12	2	6
Basic hard, 0.41 to 0.60% C.	12	10	0
Acid, up to 0.25% C. ..	14	5	0

Other Semi-products, etc.

Tin bars	10	7	6
Sheet bars	10	7	6
*Wire rods, soft basic ..	15	4	0
" hard basic ..	18	12	6
" free-cutting ..	17	12	6
" acid	22	3	6

* Subject to rebate.

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections, plates, joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast) ..	14	3	0
Boiler plts. (N.E. Coast) ..	15	0	6
Chequer plts. (N.E. Coast)	15	13	0
Angles, over 4 un. ins. ..	13	13	0
Tees, over 4 un. ins. ..	14	13	0
Joists, 3 in. × 3 in. and up	13	13	0
Rounds and squares, 3 in. to 5$\frac{1}{2}$ in.	14	13	0
Rounds under 3 in. to $\frac{1}{4}$ in. (untested)	15	8	6
Flats—over 5 in. wide ..	13	18	0
" 5 in. wide and under ..	15	8	6
Rails, heavy, f.o.t. ..	12	15	6
Hoops	16	3	6
Black sheets, 24 g. (4 t. lots)	19	7	6
Galv. cor. shts. (")	22	12	6
Galv. flat shts. (")	23	2	6
Galv. fencing wire, 8g. plain	24	7	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales ..	15	2	6
Scotland	15	2	6
Ireland, f.o.q.	15	15	0
No. 3 BARS:			
England and Wales ..	12	5	0
Scotland	13	7	6
Ireland, f.o.q.	12	17	6
No. 4 BARS:			
England and Wales ..	12	15	0
Scotland	13	12	6
Ireland, f.o.q.	13	7	6
STRIP:			
England and Wales ..	16	10	0
STAFFS MARKED BARS, f.o.t...	18	0	0

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, September 10, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley..	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
	Cents
Iron bars, Chicago	2.25
Steel bars	2.15
Tank plates	2.10
Beams, etc.	2.10
Wire rods	2.00
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., 24 g.	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

Welsh foundry	42/6 to 44/-
" furnace	31/6 to 33/-
Durham foundry	39/6
" furnace	33/5
Scottish foundry	42/6 to 47/6
" furnace	31/6

TINPLATES

f.o.b Bristol Channel ports

I.C. cokes	20 × 14 per box		27/- to 29/-
"	28 × 20	"	54/- to 58/-
"	20 × 10	"	38/6 to 39/6
"	18$\frac{3}{4}$ × 14	"	28/3 to 29/-
C.W.	20 × 14	"	25/- to 26/-
"	28 × 20	"	50/- to 52/-
"	20 × 10	"	36/3 to 37/6
"	18$\frac{3}{4}$ × 14	"	26/- to 27/-

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Brazier copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ½ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods	8½d.

COPPER TUBES, etc.	
Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	9½d.

PHOSPHOR BRONZE	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

AVERAGE MONTHLY PRICES OF FURNACE COKE D/D MIDDLESBROUGH

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9¼
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11¼
1910	0 18 4½	0 18 0	0 18 0	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 0	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 8 9	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 8 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 1 6	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 5
1920	2 12 3	2 14 0	2 19 0	3 0 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	1 8 3	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½
1926	1 2 1½	1 0 9	0 19 2½	0 18 6½	•	•	•	•	•	•	1 5 0	1 5 0	1 1 1½‖
1927	1 5 6	1 4 9½	1 6 1½	1 3 9	1 2 6	1 0 8½	0 19 4½	0 19 0	0 18 7½	0 18 0	0 17 10½	0 17 6	1 1 1½
1928	0 17 6	0 17 10½	0 18 0½	0 17 11½	0 17 8½	0 17 6½	0 17 7½	0 17 6½	0 17 6	0 17 7½	0 17 7½	0 17 6	0 17 8
1929	0 17 7½	0 18 0	0 19 0	0 19 6½	0 18 10½	0 19 10½	1 1 3½	1 1 8½	1 3 0	1 3 6	1 3 8	1 3 1½	1 0 9½
1930	1 2 0½	1 1 3	1 0 3	0 19 1½	0 17 7	0 16 10½	0 16 6	0 16 6	0 16 9	0 17 0	0 17 0	0 17 0	0 18 2½
1931	0 17 0	0 16 7½	0 16 0	0 16 0	0 15 11	0 15 5	0 15 1	0 15 0	0 15 0	0 16 9	0 17 0	0 16 6	0 16 0½
1932	0 17 0	0 16 11½	0 16 5½	0 15 9	0 15 7½	0 15 6	0 15 6	0 14 9½	0 14 6½	0 14 6	0 14 6	0 15 4	0 15 6½
1933	0 16 0½	0 15 11½	0 15 6½	0 15 6	0 15 6	0 15 6	0 15 6	0 15 8½	0 16 1½	0 17 0	0 17 6	0 18 0	0 16 1½
1934	0 19 4½	1 0 6	1 0 1½	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0
1935	1 0 0	0 19 6½	0 19 0½	0 19 0	0 19 0	0 19 0	0 19 0	0 19 0	0 18 9½	0 18 9½	0 19 5½	1 1 2½	0 19 3½
1936	1 2 0	1 2 11½	1 3 2½	1 4 0	1 4 11½	1 5 3½	1 5 1½	1 4 7½	1 4 6	1 4 6	1 4 6	1 4 6	1 4 1½
1937	1 5 6	1 5 10½	1 7 7½	1 12 9½	1 15 0	1 19 3½	1 18 6½	2 0 0	2 0 3½	2 1 10½	2 2 0	2 2 0	1 16 1½
1938	2 0 1½	1 16 7½	1 16 6	1 16 6	1 16 6	1 13 9½	1 11 11½	1 11 6	1 11 6	1 11 6	1 11 6	1 11 6	1 13 9
1939	1 8 0	1 8 0	1 8 0	1 8 0	1 8 0	1 8 0	1 8 0	1 8 0	1 8 0	1 8 0	1 13 0	1 13 0	1 8 10
1940	1 13 0	1 14 10½	1 15 6	1 15 6	1 15 6	1 15 8	1 16 11½	1 17 5	1 17 5	—	—	—	—

* Strike period. ‖ Five months.

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